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POWER

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Don't Make Dub Operators Deduce

THERE has been comment recently as to the relative merits of indicating instruments and automatic control for the fireroom.

The frequency with which expensive instruments are found neglected and out of use is noted. Even when the apparatus is kept in operation its records are too frequently simply filed as a matter of routine without intelligent analysis.

Which led a prominent engineer, in an address on power-plant operation, to advise, "Don't make dub operators deduce."

The natural reaction to this would be "Don't have dub operators anyhow."

But there are in power plants, by and large, all kinds of operators.

Some are excellent mechanics, skilled in the intricacies of running machinery. Their ears are tuned to the hum and rhythm of their charges, and almost instinctively they reach for the right valve or lever or direct the right operation in case of a departure from it.

A valuable sort of man to have in practical charge. Not at all what would be characterized as a dub.

But he may not be at all able to "deduce."

Years ago a successful operator remarked that, in the running of a power plant, "Theory without practice is not worth a damn. Practice without theory is worth some three dollars a day. But theory and practice combined are worth from three thousand a year up."

The greater size and complexity of the modern power plant, the increased cost of fuel and new methods for its saving and the growing number and diversity of services required from the power department offer, as never before, in its superintendence opportunities for this higher class of man.

If not only safety and continuity of operation but efficiency and economy are desired, a man who is capable of "deducing" should be put in charge and furnished with the instruments and apparatus that he needs.

The right kind of man will justify a good salary and pay a good dividend on the investment.

F. R. Low

POWER *Stands for . . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**

High Speeds the Order of the Day

THE ERA of the slow-moving reciprocating engine has been succeeded by the age of speed and light weight. Engineers should appreciate this condition and discard the old idea that serviceability is in inverse proportion to the number of revolutions.

Objection has frequently been raised that a high number of piston strokes means increased wear. This is by no means true, for it is feet of total piston travel rather than the number of reversals per minute that should determine wear. Experience has proved rather conclusively that even high piston speeds cannot be used to determine what the probable future cylinder and bearing wear will be.

Length of life depends upon the balance of the parts and, now that the metallurgist has made light alloys available, there is no excuse for a poorly balanced engine.

Adoption of high speeds, even if the cost of the bare machine is not decreased, does reduce erection expense and foundation costs; and the small high-speed engine calls for far less space than does its slower-speed rival.

He Made One Thing Do Where None Did Before

KING ARTHUR and all his Round Table were gathered together—knights, ladies and villains, packed closely in the public square. It was noon. In the center of the mob, surrounded by an inner ring of scowling magicians, stood Progress in the person of Mark Twain's Connecticut Yankee. He looked nervously at the sun, beating down through the coppery English haze. Did his memory serve him? Would the eclipse come off? Or was he a century out of the way in his calculations? His life depended on the answer.

A moment later a deep violet shadow had descended on the countryside. A terrible silence brooded over everything. The mob was on its knees—the magicians trembled. This Yankee had done the trick; his life was saved. Modern science had replaced old superstitions.

Many centuries later, after the World War, another American found himself in the darkness and ignorance of a Soviet prison camp on the edge of the Arctic circle. Ten years of solitude faced him. But again the indomitable Yankee spirit reached out to bring modern enlightenment into the Arctic night. He built a power plant with his own hands from scraps of metal and rust-eaten machinery. He lighted the camp with electricity made by rickety boilers and a conglomeration of obsolete junk, thus preventing the murder and villainy that would have flourished in the dark. Out of nothing but ingenuity and inadequate raw materials this man brought modern conditions to a backward corner of the earth, and as a result he gained his freedom.

"Cheaper power through modern equipment"? Well, no. In this case, light out of darkness, freedom after imprisonment—symbols of modern enlightenment just as surely as though the job had been planned on a New York drawing board and carried out by an army of trained engineers. To make one thing do where two did before—so we preach today. But is this any different from making one crude thing do where *none* did before? It is progress just the same, and that is the basis of all improvement and of the supremacy of the enlightened over the ignorant.

Rough and Ready Heat Balance

THE heat balance of a certain piece of equipment is a statement of the portion of the total heat supplied that is converted into useful output and of those portions that appear as individual losses. Frequently, unaccounted-for items are grouped with radiation losses to complete the balance. The usual heat balance is based on the results of comprehensive tests which involve much time, labor and expense. In many cases such elaborate and costly tests are not justified. As a result many central-station operators have developed simple methods of approximating heat balances that deserve far more extended use in power plants.

These estimated heat balances are based on observations taken often as part of the regular plant operation and from which individual losses may be determined. For instance, in the case of boilers the coal analysis, together with the flue-gas analysis and flue temperature, permits the calculation of flue-gas losses, of hydrogen losses, of losses due to moisture and losses due to carbon monoxide. Heat losses from carbon in ash or in flue dust can be found by sampling the ash and the flue gases and from operating records of total coal burned. Other losses, such as radiation, air leakage, etc., can be estimated and the boiler efficiency determined by differences. With accurate observations the results are useful.

Similar efficiency values for steam turbines, turbine generators and other plant apparatus can be found by a measurement of the individual losses.

The simplicity of these methods compared with elaborate long time tests, and the valuable data gained on regular plant performance, should encourage a still wider use of these methods of loss determination as a means for checking the efficiency of power units.

Code for Rating Low-Pressure Boilers

MUCH confusion has existed in the heating field as to the capacity ratings given low-pressure boilers. No two manufacturers express the capacity of their products on a comparable basis, and in many cases selection of the proper boiler size is impossible if rating data alone are considered. This condition has led to many mistakes and frequent lack of capacity.

At the recent annual meeting of the American Society of Heatng and Ventilating Engineers a code was adopted for rating low-pressure heating boilers burning solid fuel. In general it provides that a boiler shall be rated at its B.t.u. output when the flue-gas temperature and the rate of combustion per square foot of grate are as given by curves in the code. It is provided that during test the flue gas must contain not less than twelve per cent CO_2 when burning anthracite and ten per cent when burning bituminous coal, and that priming shall not exceed two per cent moisture.

It is the intent of the code to furnish comparable boiler ratings that will meet average conditions and assist those who do not desire to make comparisons of boiler performance curves.

The Society is to be commended for the preparation of this code, and it is hoped the boiler manufacturers will co-operate with the A.S.H. and V.E. in its endeavor to bring some order out of the present chaos in the capacity ratings of low-pressure boilers.

Pulverized-Coal Furnace Explosions

TWO or three recent pulverized-coal furnace explosions of a serious nature have led to an exchange of experiences among operators, from which it develops that such explosions have been far more numerous than was supposed. In fact, they have been so numerous as to lead some of the insurance companies to prepare special furnace explosion policies.

A few years ago, when pulverized coal began to gain headway among steam generating plants, there was considerable apprehension as to the explosion hazard, this fear being based on some disastrous accidents in the cement industry, where pulverized coal had long been used. Accordingly, experts were drafted to prepare a Safety Code. After many hearings and revisions such a code was formulated under the sponsorship of the underwriters and the Bureau of Mines, and accepted by the operating companies. This code appears to have been followed pretty generally as to the installation of equipment, with the result that the average steam plant today presents a marked contrast in cleanliness to the old cement mill, where coal dust accumulations were common.

The removal of this visible hazard, however, may have been responsible for less precaution in operating procedure, for several of the recent explosions appear to have been traceable to negligence in operation.

Such accidents are unfortunate, but they should not serve as an indictment of pulverized coal. It would be just as logical to condemn the use of boilers because there have been boiler explosions. It is possible to burn coal in pulverized form safely, provided certain rules are followed as to design, installation and operation. The way to keep down the hazard is to disseminate among operators the lessons taught by these explosions. An attempt to cover them up will tend to increase rather than decrease such occurrences by depriving other operators of this knowledge and might easily do harm to the cause of pulverized coal.

Watch the Maximum Demand

KEEPING down power costs attracts ever-increasing attention. This problem has many ramifications, some of which involve large expense for remodeling power generating, distributing and application equipment. In other cases material saving can be accomplished at practically no cost. Where power is purchased, large savings can frequently be realized by keeping down the maximum demand.

Frequently, peak loads can be controlled at the cost of a load survey to find their causes, followed by an operating schedule to keep the peak demand at a minimum consistent with load requirements. This can be done by rearranging machine operating schedules or by shutting down, for short periods on the peaks, machines that are not required to be in constant service. These shutdowns may be taken care of automatically, at small expense, and the peaks not allowed to exceed a predetermined value.

When power is purchased, the cost is frequently looked upon as fixed by the rate. This is true only so far as the rate is concerned. In many plants a study of the load conditions will reveal opportunities for making large reductions in power cost, by improvement in the applications and by controlling the maximum demand. A ten per cent. reduction in the power bill by this method will frequently save fifteen or twenty per cent. in power costs. It also leads to more careful attention to other operating details that contribute to lower production costs. Control of maximum demand has been applied under a wide variety of conditions and the savings have been surprisingly large in many installations.

Where power is generated in an industrial plant, peak loads may not be so important as when power is purchased. But if the plant is approaching its safe load capacity, study of the maximum power requirements may show how to put off the day when additional generating equipment must be installed. Even when there is sufficient capacity, keeping down the maximum demand may allow the load to be supplied with one less machine, and thus improve the operating efficiency. In any case it pays to watch the maximum demand.

Yankee Prisoner *Builds a* POWER PLANT IN RUSSIA

By J. C. Chevalier

THE rusting wreck of a light cruiser, a junk pile of dilapidated copper kitchen utensils, a pair of cathedral bells, a few acres of scraggy timber and a peat bog, even though they be supported by unlimited and willing labor, offer very little to an embryonic Steinmetz facing the problem of building and maintaining a 3,000-kw. power station.

The old cruiser was beached on the icy shores of Greater Salofky Island in the White Sea; the copper kettles and church bells were bequeathed to the Soviet Union by the fugitive monks, who in more peaceful days occupied the great granite "Kremlin" that stands on the island and is flanked by the peat bog and the scraggy timber; eight and a half thousand starving, freezing political exiles—thief, beggar, counter-revolutionary, prostitute and ecclesiastic—comprised the willing labor—willing because to work meant better grades of food in proportion to services rendered. And even the young Steinmetz, himself a counter-revolutionary exile and imbued with an earnest desire to survive the hardships of ten years of forced labor in an arctic prison camp, had no alternative but to produce something out of what appeared to be nothing. Thus, simultaneously with the power station there arose a foundry, a machine shop, a smithy and a brickyard. The residue furnished the major portion of the equipment installed later in a tannery, sawmill and shoe factory.

A neighboring island yielded limestone for burning, but a thorough search of the settlement discovered not a single person with even the most rudimentary knowledge of the art of making brick. The monks had manufactured an excellent brick of the variety known in Russia as *jelesnyak* (iron-like), and near their abandoned clay pits stood a mixer crudely fashioned of wood and fitted with a long wooden boom to which they had evidently hitched draft animals.

I—for it was I who was the young man with the problem—was launched straightway into the production of brick, equipped with such knowledge of ceramics as experiments with mud pies as a boy in Texas had

J. C. CHEVALIER was born Jan. 3, 1893, in the City of Gainesville, Texas. His father was manager of the town's water system and in the pumping plant and repair shop he found his first mechanical training.

On the outbreak of war in 1914 he made several trips from New Orleans to England as a cattle-boat foreman. He settled in Manchester and worked for a while with the British Westinghouse Company as assembly foreman in the alternating-current motor department.

In 1915 Mr. Chevalier joined the British Royal Field Artillery as an artificer, and served for five years at the front. His last period of army service found him in the town of Batoum in the Transcaucasus. After demobilization he returned to Batoum as the superintendent of an oil station owned by a large American firm. On the entrance of Soviet troops into Batoum the station was confiscated, but Mr. Chevalier remained to settle personal business.

He was a frequent visitor to out-of-the-way places in the Caucasus, being drawn by their interesting historical associations. These visits and the natives' friendly attitude toward him attracted the attention of the Bolsheviki. They became suspicious, and during an uprising of the local peoples in 1924, Chevalier was arrested and charged with American espionage and a number of other and equally fictitious crimes. He was sentenced to death by the Special Committee of the "Tche-ka" (Secret Police) without a hearing. This sentence was subsequently commuted to ten years in the Arctic Camp on the Island of Salofky.

Unofficial outside influence effected his ultimate release after two years and a half of imprisonment.

given me. The island is on the skirts of the Arctic zone, and winter seems always to be either just coming or just going. It was soon discovered that air-heated sheds were indispensable for seasoning the brick before kilning. They were built, and after several disastrous but instructive experiments, the yard produced good brick, but at its best it never rivaled the quality imparted by our monkish predecessors. In the absence of cattle the mixer was rigged with a second boom and, adequately manned by convicts, functioned most satisfactorily. Making brick, from digging the raw material to stacking the finished product, was adjudged comparatively light work, as was the cutting and drying of peat. Women prisoners were delegated largely to perform these tasks.

The check-up on resources brought to light the information that the old monastery grist mill, although equipped with a low-pressure water turbine of 150 hp., designed to drive three pairs of stones and a screen, was operating under the new régime on one pair only. Here was obvious waste. The stones were brought temporarily to a standstill and the turbine was removed to a site suitable for the power station. The stream was deflected, the turbine coupled to a motor purloined from a deserted sawmill on the mainland, to do as a generator, the whole housed in a shack of sawmill tailings, and the first unit went into operation with a capacity of about 80 kw. Power derived therefrom drove the equipment of our wretched machine shop and smithy and lighted the location well enough to permit working day and night. There were but two shifts to the 24 hours.

Repeatedly, the ranks of the prisoners were culled for skilled artisans, and time after time it was reported to the camp administration that the work was being delayed by a lack of some certain specialist. Following such a complaint, the next batch of prisoners arriving from Moscow never failed to disgorge several workmen of the sort needed. This was an astounding and constantly recurring coincidence. Even when our best doctor died, it luckily happened that a clever doctor at liberty in Russia became so radically counter-revolutionary in his convictions that it was deemed imperative that he be exiled to Salofky forthwith.

Winches and donkey engines were unknown, and cranes and derricks were operated by means of great wooden capstans manned with scores of half-naked unfortunates tramping Samson-like and barefooted in a never ending circle of freezing slush at the end of a rough hewn boom.

The *Kabistan,* or capstan, was generally fashioned of rough hewn timbers dovetailed together, and consisted of three principal parts which, when assembled, were held in place by large wooden pins. The U-shaped frame, as shown in the sketch, was firmly mounted on heavy skids. The top, or yoke, was in two pieces so that it might be clasped about the spindle after the latter had been slipped into the hole in the bottom cross-timber. The whole was reinforced with iron bands and furnished with eyes and rings by which it could be anchored to a "dead-man."

When in use a fall was given several turns about the spindle and the latter was rotated by means of poles passed through the capstan head. After a few turns the rope would climb up to, and bind against, the yoke. It was then snubbed with the short length of rope attached to the frame, the purchase was lowered and the operation repeated.

The apparatus demanded frequent and copious lubrication, which was supplied in the form of a soap which the camp manufactured from seal blubber and ash.

Contrivances, similar in principle, made it possible to open and close the sluices on the turbine water system and the gates to a small dry dock. By these primitive methods great portions of the old cruiser were dragged half way across the island, a distance of six versts, to the "Kremlin." Over this road came two marine boilers, two compound steam engines, several generators in a fair state of preservation and tons of other salvage. Even the ship's stacks were dismantled and later assembled end to end to serve the station.

It is surprising with what unbounded confidence seemingly impossible problems are tackled when there is a total absence of responsibility. My abilities were sadly limited, but they were superior to those of all the others. Hence there was no fear of methods being criticized so long as the ultimate results were satisfactory. Compensation for special work such as this took the form of forced rations—extra ounces of black bread, sunflower seed oil, salt codfish and buckwheat. The more food the better the chance to outlive the last day of one's sentence. There was no end of aspirants for such work and compensation, and they gambled like the poor princes in the fairy tales. Success spelt ease and a full stomach, but failure brought inevitable retribution in the guise of an extension to the current sentence of from three to five years.

Foundations down, the two boilers were dragged into place and bricked up. The hybrid stack was laboriously coaxed into the perpendicular upon the base built of the first fruits of the new brickyard. This done, the erection of the building proper and the installation of the two compound steam-electric units began.

A store of cement had been left on the island by the British on their evacuation in 1918; of boulders there was an almost inexhaustible supply; the brickyard flourished and the walls grew apace.

Busbars and switch blades were cast from the bells and copper kettles and painstakingly finished by hand. Files were a rarity, and new ones were used only for the finest work. Routine jobs were done with home-made improvisations forged and cut from any and every thing that would hold any kind of a cutting edge for any length of time. Three men did nothing but anneal, recut and retemper old files.

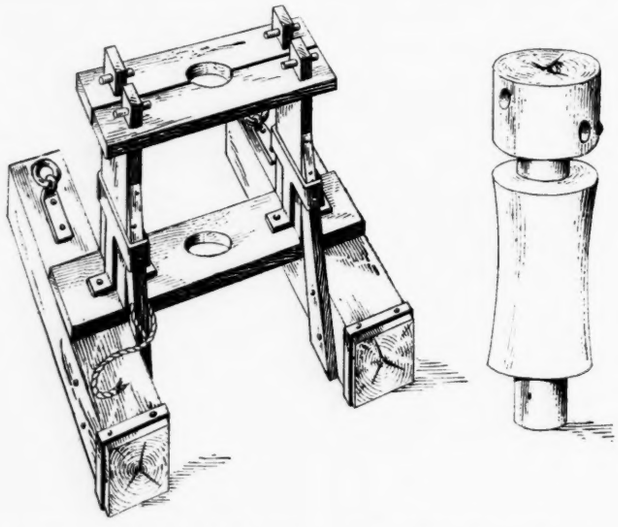
Seldom does the Connecticut Yankee at King Arthur's Court appear in these modern days of thorough and widespread engineering knowledge. But here was a man who, by his ingenuity, resourcefulness and courage, played the magician in the midst of untutored Russian exiles in Siberia, and thus made sure his escape from political imprisonment.

Mr. Chevalier contributes another article to an early issue of *Power.*

It was necessary to use green hand-hewn timbers for the station, but for the switchboard sills we obtained beams that had been drying for scores of years in the walls of the old monastery wings. From these same walls came the marble for the panels and bus supports, great slabs of beautifully polished stone that had been contributed by wealthy pilgrims to the holy place.

Stone and masonry were drilled with core-drills fashioned from remnants of wrought-iron pipe, one end of which we filed with teeth and swedged out. The teeth were then coated with a film of molten metal made from cast-iron filings at a temperature just high enough to melt the filings without deforming the teeth. These drills gave wonderful results.

Tension springs for brush-holders on the generators were in most cases lost or stolen from the machines. These we could not replace in bronze, but carefully re-



This "home-made" capstan, devised by the author, took the place of tractor and crane for handling heavy loads

produced in thin sheet iron, which we hardened by a process used commonly in Russia. The articles to be treated were placed in a length of pipe together with hoof-parings, leather scrap, bone-ash, a few cast-iron filings and a little bluestone, and the whole tightly sealed with damp clay. The container was then brought to a white heat and held there for a length of time dependent upon the thickness of the articles. It was then removed from the fire and the contents chilled in oil. All manner of small springs were made in this way from soft iron sheet and wire—a primitive though effective method of carburizing.

The finished station had a capacity of over two thousand kilowatts. The first success inspired confidence. Every imaginable type of machine was represented in the chaotic pile of junk that had grown with each returning prison transport. The best was always segregated and added bit by bit to the original installation, and when the capacity named was reached, the floor held twelve generators. They were driven in pairs and individually, directly and with transmission. Some were hooked up in series and others in multiple. Some were rated at 110-130 volts, others 220-240 volts, and two were Siemans three-wire machines with both voltages.

There was a Fairbanks-Morse gas engine, an Otto semi-Deisel, an Atlas vertical steam engine, a similar machine of ancient Russian vintage, two low-pressure water turbines and last, but best of all, the two compound steam engines from the vessel. They bore no identifying marks whatever excepting some undecipherable Japanese inscriptions.

The station was protected from the line with the only two overload circuit breakers that we possessed, one a General Electric and the other a Westinghouse. No protective measures were possible with the individual machines. When potential fell on a machine, it was lost and the station went out. At the first groan the distributing bus load was tripped at the breakers and the units cut out one by one from the station bus. Swapping polarity meant time lost in changing leads, etc., for only one generator was equipped with a double-throw switch. By means of an auxiliary system we were able to energize the fields of all the other machines from this one. Once the juice was shot to them, we were certain that their polarities were all alike. They were then cut one by one into the line and the load was again taken up.

The old cathedrals each held from six to eight hundred of the worst and most desperate prisoners in the camp. Darkening of the lights in these quarters was a signal for wholesale murder and ration high-jacking. When an emergency called for lightening the load, the cathedrals were always the last to be cut out and the first to be cut in. The wooden barracks that housed the women prisoners were the safest group to drop, but even there darkness sometimes precipitated a riot.

Feeders pieced out from short lengths of cable of all sizes, some bare and some insulated, were slung from poles on home-made terra-cotta insulators. The poles we felled and dressed ourselves and erected in the frozen ground with the utmost difficulty. The cold was terrific —minus 45 deg. C.—and outside work, especially splicing, was misery. A stray strand of wire from a cable splayed out for a splice and coming in contact with one's face, would leave a painful welt, and pliers would burn the bare hands.

On occasions the wind blew with dreadful intensity, and on one instance a heavy solid copper wire was deadended three times on a 50-ft. pole only to break before the lineman reached the ground. He had poorly calculated the sway of the pole with the added surface of his body, so that when that was removed the pole reasserted itself with a force sufficient to part the wire.

Fuel was my most difficult problem. The boilers, too, were of the horizontal marine type designed for burning coal. They were supported, when first put into operation, by a "Richard Pole" water-tube stationary boiler, which was subsequently dropped for urgent repairs, the need for which had caused it to be discarded as useless by the monks.

An enormous quantity of peat and wood was consumed daily by these two boilers, and they gave, withal, but poor service. Steam could not be maintained at the desired pressure on the peak load, notwithstanding the fact that the demand was far less than the rated capacity of the two units.

The point of useful combustion was found to be about halfway up the stack. The use of dampers only made matters worse. Tearing out a baffle built into the rear of the firebox helped but little and more fuel was consumed.

I decided to lengthen the firebox by building an addition to the front, similar to a scheme for burning bagasse of which I had once read. The fireboxes were extended

to the front for a length of six feet and the results were so pronouncedly favorable that the gang of wood-trimmers that had been passing fuel to the firemen was cut in half. Previously, fuel had been three of wood to one of peat with 100 per cent wood on the peak. With the new extension we were able to burn a fifty-fifty mixture normally with two of wood to one of peat on the peak.

This settled, we began the repairs on the water-tube boiler. The drum was in a desperate condition. One plate was corroded to a depth nearing penetration. It was a bottom plate near the front and without fittings. I decided to replace it.

Skids well greased with seal blubber were set up and, the dismantled drum was slid down from its perch and out into the yard through the boiler-room door. There it reposed on cribs of heavy timbers prepared beforehand.

The faulty plate was ripped off and a new one cut from the old cruiser. The new plate was cut to a length far in excess of the dimensions of the opening. This was necessary because it gave a greater leverage to bend the patch into place.

The following method was used to get the bend: One longitudinal edge of the plate was drilled and fixed in place on the drum. The drum was rotated until the tangent plate was about 25 deg. from the horizontal. A long timber passing between two logs thrust into convenient handholes in the ends of the drum rested on the ground and securely held the whole structure. The actual bending was then done by means of two timbers about 40 ft. long, trussed in the middle for additional strength. These were placed on the plate with their major length protruding in the same direction as the loose end of the plate. The shorter ends were anchored to two capstans through blocks, as were also the long ends. As the forward capstans were rotated the rear spindles were paid out but to a lesser degree, for the timbers themselves were almost sufficiently elastic to give the required bend.

As the patch was bent little by little, the holes were drilled from the inside by hand and fixed with bolts. The drum was shifted six or eight times and several long timbers were broken, but after two weeks' labor the plate was in place and held by bolts and temporary rivets. The extra length was cut off and it seemed that the job was a success.

At this point the work was halted, for it was the month of June and the ice was beginning to rot, heralding the approach of the ice-breakers bearing new prisoners to take the place of the 3,400 who had succumbed to the cold and privation of the departing winter.

The new station had made light houses possible and it was thought best to hasten with their construction. As usual I was delegated to carry on the work, but had scarcely begun when I was notified of my impending release and was rushed to Moscow, from which place I was shipped to the Baltic States and freedom only after six more tedious months of waiting.

Canada Saves Coal

It has been computed that the coal saved by water-power installation operated in Canada during the year 1926 amounted to 17,000,000 tons, and of this amount 11,300,000 tons was saved by hydro-electric central stations. At six tons per installed horsepower, the coal equivalent of the full capacity of water power now developed in Canada would be in excess of 27,000,000 tons per annum.—*From report of Dominion Fuel Board.*

It All Comes Down to Condenser Loss

TWO approaches are always possible in studying the efficiency of any machine or plant. One is based on the primary definition of efficiency as output divided by input. The other takes account of the obvious fact that output equals input minus losses. One may approach the efficiency problem by a direct attempt to get more output from a given input or to reduce the input for a given output, or one may start to investigate the individual wastes or losses, knowing that as these are reduced the efficiency must rise. In general the second mode of attack is the more effective, particularly in dealing with complex power layouts.

The chief power-plant losses may be grouped broadly as follows:

Flue-gas losses.
Radiation (from all equipment).
Exhaust heat discharged to waste.

The extra efficiency of a condensing station over that of one exhausting to atmosphere is due simply to the fact that there is less heat in the steam discharged to the condenser than in that discharged to atmosphere.

Plants exhausting to process owe their remarkably high efficiency solely to the fact that the condenser loss (or the higher atmospheric-exhaust loss) is entirely eliminated.

High-Pressure Plants

This much is pretty well understood by all power engineers. It is not always understood, however, that the advantage of the high-pressure condensing plant over that operating at "normal" pressures can be explained in the same way.

Expansion from higher pressures produces wetter exhaust steam with a consequent reduction in condenser loss. This may not seem to apply in the usual case where the steam is reheated after passing through a high-pressure turbine. In such cases the steam reaches the condenser with the same moisture content and the same heat per pound as in a normal pressure plant. The exception is only apparent. Reheating means a substantial increase in the heat *supplied* per pound of steam. Thus the same heat per pound in the exhaust to the condenser is a smaller *percentage* of the heat per pound supplied to the steam, and the total amount of heat rejected to the condenser is a smaller percentage of that in the fuel burned.

Effect of Turbine Efficiency

The same reasoning may be applied in the case of the choice between more or less efficient generating units. With the same heat in the initial steam in both cases, the more efficient unit will abstract more heat from each pound of steam and therefore discharge less heat to the condenser.

Again take the case of a loss of station efficiency due to low quantity or high temperature of circulating water. This runs up the exhaust pressure and permits less expansion of the steam so that each pound of exhaust steam contains less heat. Therefore more heat is lost to the condenser in spite of the fact that the smaller amount of water at a lower temperature is less effective as a heat remover.

It may safely be taken as a general rule that anything that reduces the percentage of total heat in fuel thrown to waste in the exhaust increases the over-all plant efficiency.

Concentration Control

Provides Good Quality

BOILER FEED WATER

By Lucius A. Fritze and Elwood W. Scarrit

Respectively executive engineer and chief chemist, Elgin Softener Corporation, Elgin, Illinois

METHODS of water softening, limited to the purification of the feed-water supply alone or to adding treatment chemicals without consideration of the byproducts formed do not conform to modern conceptions of safe feed water. Chemical reactions of primary importance taking place within the boiler, whether in the production of sludge or in changes in soluble salts, introduce dangers from uncontrolled caustic in boiler water. Concentration control is essential, and its importance establishes the value of certain deconcentrating equipment and the control of reactions within the boiler. In this method the individual boiler, rather than the entire boiler plant, becomes the unit.

Water softening involves chemical changes, the nature of which depends upon the softening method in use. The elimination of scale-producing salts and the substitution of the soluble salts of sodium is but a partial solution of the problem of providing suitable boiler water. Under certain conditions soluble salts present a more serious problem than insoluble. Hence, in softening a feed water it is necessary to know the nature of the salts remaining in the water after the softening process. The softening of water with the aid of mechanical equipment outside the boiler, or by means of chemicals or boiler compounds within the boiler, has one primary objective—the removal of scale-producing salts either by precipitation or by changing them to a soluble form which will prevent incrustation. External softening introduces a comparatively high concentration of the soluble salts of sodium and a smaller amount of insoluble salts, whereas the internal method of treatment introduces a considerable concentration, both of soluble and of precipitated matter. The evaporation of water so treated requires means to provide properly controlled concentrations, and the problem immediately becomes one involving each boiler, thereby establishing the individual boiler as the unit.

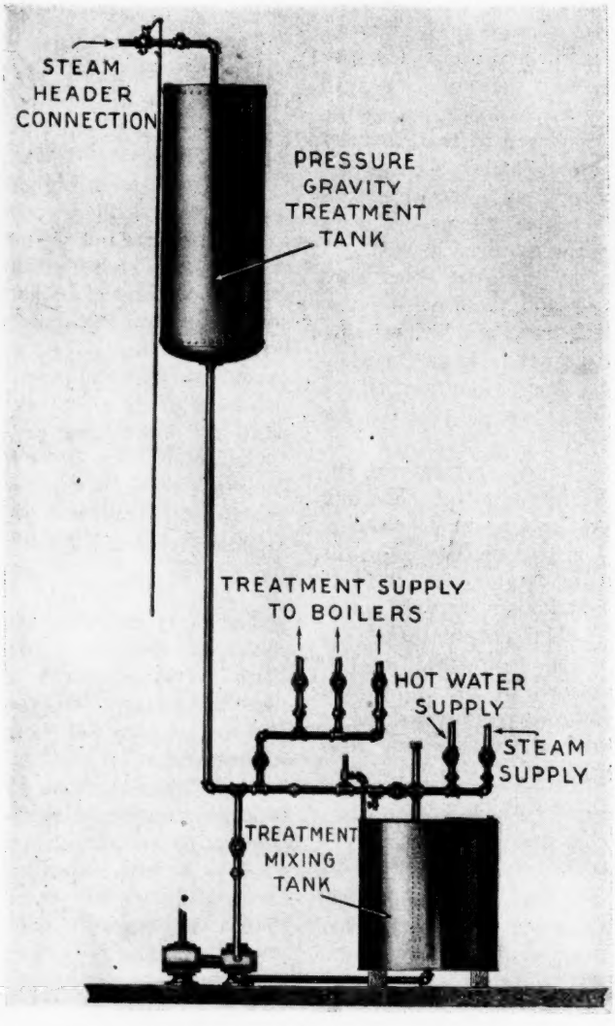


Fig. 1—Single-tank pressure-gravity treating system for proportioning chemicals to each individual boiler

Insoluble concentration is defined as suspended matter present in the feed water or as salts that come out of solution in the form of boiler sludge. Suspended matter represents the concentration most easily controlled. The water-softening procedure that introduces the maximum quantity of insoluble concentration and the minimum quantity of soluble salts, establishes the basis for efficient separation and the most satisfactory boiler water.

Soluble concentration

is defined as those salts remaining in solution at boiler temperature. The soluble salts of sodium constitute the usual soluble concentration present in boiler water. The effect of such salts in boiler operation is influenced by the particular sodium salt present. Those salts of sodium that contribute to alkalinity are of primary importance in view of the potential danger of uncontrolled caustic.

Standard water-softening methods introduce six individual sodium salts. Internal treatment with chemicals or boiler compounds introduces additional sodium salts. The continuous-blowdown method for the removal of a portion of the boiler water to minimize the soluble concentration is faulty in that the individual properties of each sodium salt are overlooked and the soluble concentration is considered as a unit mass.

Sodium sulphate and sodium chloride, contributing to mass concentration, differ from sodium nitrate, which introduces corrosion, and the carbonate, bicarbonate and hydroxide of sodium, which introduce causticity. Except under the most favorable conditions wherein the sulphate of sodium predominates, chemical control is necessary to establish a minimum causticity and to maintain the correct sulphate-alkalinity ratio for the prevention of embrittlement. Soluble concentration, therefore, introduces factors that of necessity require chemical control in contrast to the insoluble concentration which is removable.

Because each boiler represents an individual problem in the control of concentration and boilers of identical construction operated on waters of dissimilar mineral constituents present separate problems, the question comes up of when a boiler is in proper control and capable of delivering its maximum capacity of dry steam.

For each individual boiler there is an optimum operating concentration at which the highest overload may be realized without the danger of wet steam. Investigation of operating concentrations discloses an equilibrium constant for each individual boiler and, when maintained, provides the concentration control necessary for suitable operation. The equilibrium constant is obtained from the equation,

$$K_e = \frac{C_i \times C_s}{f}$$

in which K_e is the equilibrium constant; C_i represents the coefficient of insoluble concentration, defined as the ratio between the suspended matter in the boiler water and the potential sludge producing matter in the incoming feed water; C_s is the coefficient of soluble concentration, defined as the ratio between the concentration of soluble salts in the boiler water and the concentration of salts in the feed water that will remain soluble within the boiler, each ratio being calculated for the optimum operating concentration for the boiler; f represents the factor of evaporation and is proportional to the quotient of the evaporation divided by the heating area.

This equilibrium constant is determined by a survey analysis of the boiler conditions at the plant. The constant is subject to slight error in the absence of consideration of the deposition of scale and the ratio of blowdown to incoming feed water. Field conditions, however, at best involve an error, and the constant is accurate within the allowable limits of error in steam-plant operating conditions.

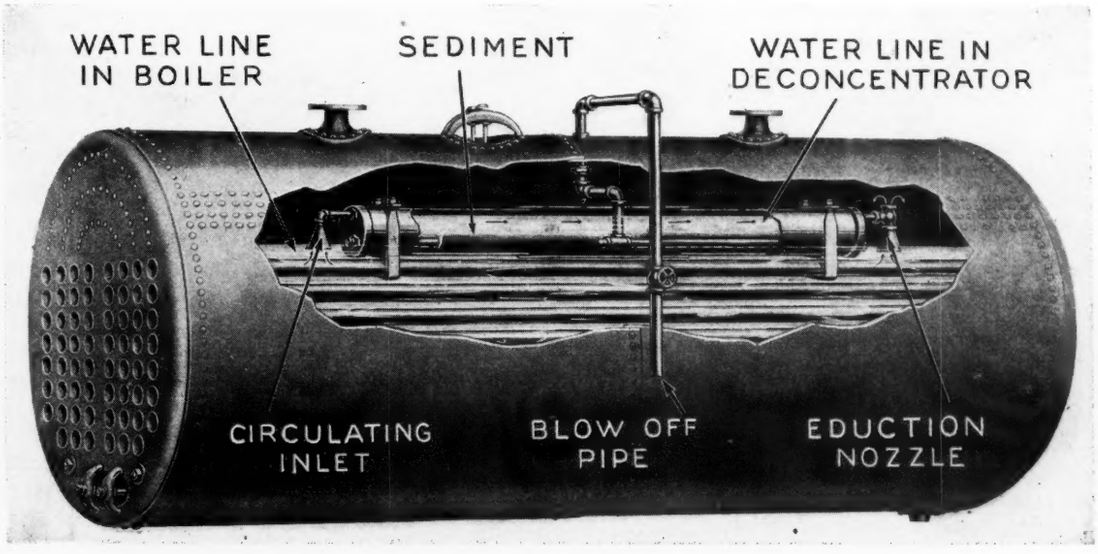


Fig. 2—Deconcentrator system with precipitating tank placed within a tubular boiler

The presence of sodium bicarbonate or sodium carbonate in feed water results in a high concentration of caustic alkalinity in the boiler. Water-softening procedure usually introduces into the feed water one of these sodium salts, which, under the high temperature in a boiler, breaks down to caustic soda.

Investigation has disclosed that the presence of uncontrolled caustic in the boiler water leads to embrittlement. Further, it has been determined that to minimize the effect of caustic in the boiler, a definite ratio between the sulphate content and the alkalinity must be maintained. A safe sulphate ratio has been established for each working pressure, and with increasing pressures proportionately higher sulphate ratios are required. The use of other salts, such as tannates and phosphates, for the prevention of embrittlement is still in the experimental stage. It is for this reason that the sulphate-alkalinity ratio has been accepted in boiler-water conditioning as the only safe index in the prevention of embrittlement.

It is evident that in allowing a high alkalinity to develop in a boiler, a greater concentration of sodium sulphate will be required. A critical condition is reached with high alkalinity wherein the proper ratio establishes

an excessive soluble concentration; or, in the absence of the proper ratio, protection is not provided against embrittlement.

For the proper control of concentrations the initial procedure is to provide the correct means for conditioning the feed water. Water-softening methods designed to convert scale-forming salts to soluble salts introduce the component elements responsible for high caustic alkalinity. Correct conditioning minimizes the alkalinity, and, in so doing, reduces the soluble concentrations in the boiler, thus facilitating the prevention of embrittlement.

Available means for the control of concentrations in boiler water include deconcentrating equipment and the continuous blowdown system with heat exchanger. Deconcentration involves the definite chemical control of reactions within the boiler to produce the maximum quantity of suspended solids or sludge, and the continuous circulation of a portion of the boiler water to a settling tank where the suspended solids deposit and from which the clarified water returns to the boiler.

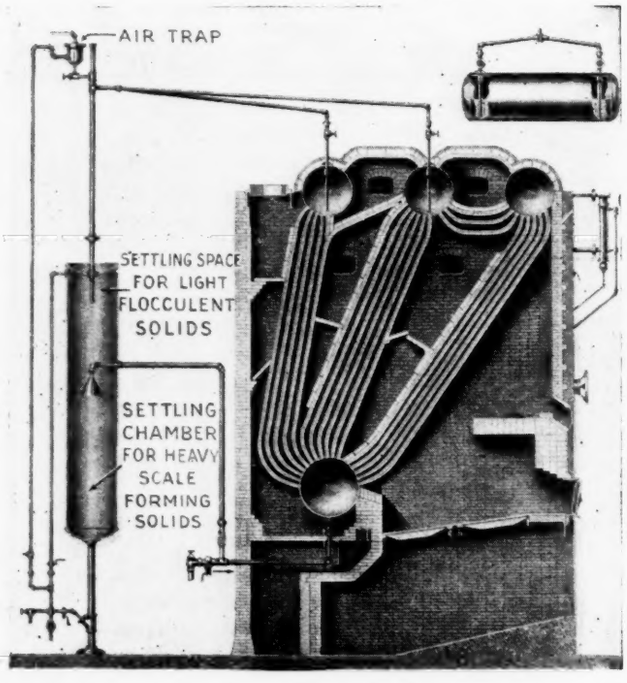
Continuous blowdown, with the transfer of heat units to incoming feed water by means of a heat exchanger, is a dilution method. The dilution process involves the removal of a portion of the boiler water and its replacement with fresh water, whereas deconcentration provides for the separation and removal of impurities without the waste of the purified water.

Type of Concentration Decides System

Each system has definite and specific fields of usefulness. A problem involving insoluble concentration is controlled to the best advantage by deconcentrating equipment, whereas a problem involving soluble concentration is more efficiently solved by the continuous blowdown system with heat exchanger.

Selection of the correct system for controlling the concentrations of boiler water is influenced by the mineral constituents of the raw water. When the mineral impurities in the raw water are of such character that insoluble concentration will result, producing sludge within the boiler, the softening method that brings about this reaction should be selected and deconcentrating equipment used. Water containing mineral salts that cannot economically be converted to sludge within the boiler introduces soluble concentration, and under such conditions the continuous blowdown system with heat exchanger is more desirable.

Fig. 3—Deconcentrator system for water-tube boiler with external precipitating tank



The presence of return condensate does not influence the type of equipment required in the solution of the concentration problem. The presence of return water introduces a time factor, in that a boiler operated on all raw water will reach a given concentration twice as rapidly as a boiler operated with 50 per cent return water.

Operating Economy Is a Governing Factor

Selection of concentration-control equipment emphasizes further the importance of utilizing the proper water-softening procedure to secure the greatest economy in operation. A method that substitutes soluble concentration for the insoluble, aggravates the problem of control and defeats the fundamental purpose of providing a suitable boiler feed water.

Deconcentrating equipment is designed to separate insoluble concentration from the boiler water without waste of blowdown. The equipment consists of a settling tank placed outside the boiler, through which is continuously circulated definite quantities of boiler water. Insoluble concentrations composed of suspended matter settle to the bottom of this tank, and the clarified water returns to the boiler. A drain line is placed at the base of the settling tank and, periodically, the accumulated sludge is removed by the opening of a drain valve.

Average operating conditions permit the circulation of a quantity of boiler water equivalent to from 25 to 50 per cent of the hourly evaporation, and under severe conditions the equivalent of 150 per cent of the hourly evaporation may be removed from the boiler, clarified and returned. The use of a filter bed for the removal of the suspended matter has been attempted, and in some cases ejectors and pumps have been used to circulate the proper volume of boiler water. Experience has disclosed that filter equipment is not necessary in the clarification of boiler water and, further, that adequate circulation may be provided without the use of pumps or other mechanical means.

The quantity of water removed from a boiler is determined by the amount of the evaporation and the quantity of insoluble concentration to be removed in order to maintain the boiler in proper equilibrium. The capacity of the deconcentrating equipment, the settling area, the supply points, transfer pipes and return lines are likewise determined by the same factors.

Removal of insoluble matter is accomplished equally well by the use of an internal deconcentrating system wherein the settling tank is placed inside the boiler. The limiting factor for the internal equipment is the available drum space, and hence the internal equipment is effective where drum capacity and evaporation permit proper sedimentation.

Correct condition of the feed water in conjunction with deconcentrating apparatus provides clean boiler water with a low coefficient of insoluble concentration and constitutes the initial step in the production of clean steam.

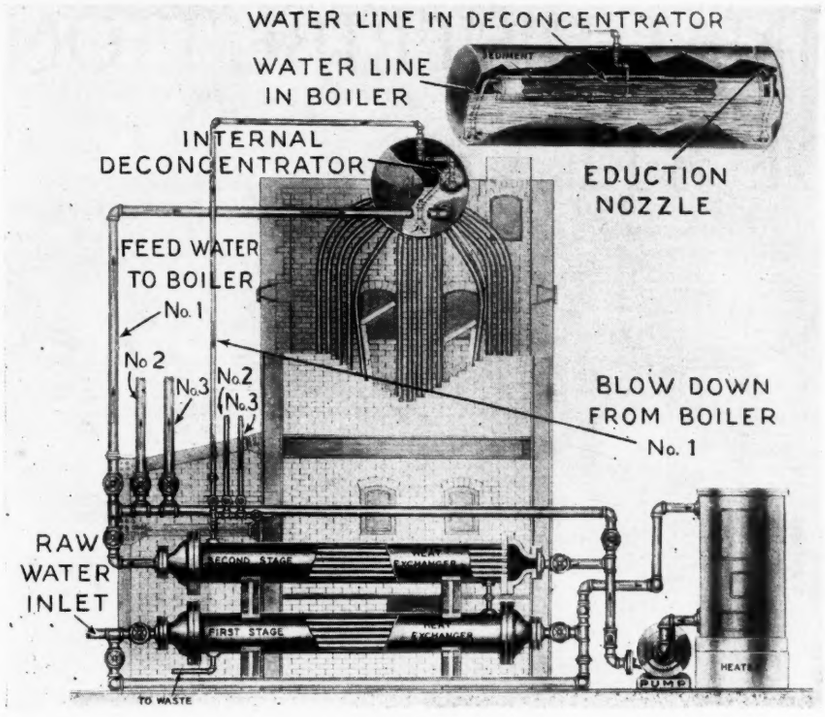


Fig. 4—Continuous blowdown system using internal deconcentration

Presence of oil in boiler feed water, aside from the insulating properties and the deleterious effect on hot boiler metal, introduces a medium the property of which is to accumulate in an aggregate mass the insoluble concentration that will deposit in the form of scale. The most carefully conditioned feed water may be influenced seriously by the presence of oil and means are required to remove oil contamination.

Grease, containing the fatty elements, saponifies in the presence of caustic alkalinity at the high boiler temperature. In addition to the adhesive properties of grease and oil, saponified grease or soap changes surface tension and causes foaming. Unlike insoluble concentrations which are readily controlled, oil and grease respond less easily to removal and thus increase in concentration within the boiler.

Oil filters or separators, at best, provide but partial removal with the result that a portion of the oil in the feed water reaches the boiler. In view of the cumulative properties of oil the presence of but a small quantity in the water, after the feed water has passed through an oil filter, will prove troublesome in boiler operation. Thus, in the control of insoluble concentrations, it is of particular importance to provide means for removing the entrained oil.

Oil Filters Should Be Used with Deconcentrating Equipment

Deconcentrating equipment may be adapted readily to remove entrained oil or grease within definite limits of concentration. Such equipment, however, is not a substitute for the oil filter, and removal before the feed water reaches the boiler is advisable. Feed water containing oil contamination should be filtered, but the oil present after filtration necessitates coagulation and removal from the boiler by means of deconcentrating equipment.

Mineral salts present in many feed-water supplies, under correct softening procedure, established a predominating soluble concentration wherein the continuous blowdown method is preferable to deconcentrating equipment, in the control of the boiler water. The continuous blowdown system with heat exchanger has a definite field of usefulness in the control and regulation of soluble concentrations. The continuous removal of a definite quantity of the boiler water and the utilization of the heat units to increase the temperature of the incoming feed water permit larger blowdown than otherwise would be feasible or practical. Dilution with incoming feed water permits the optimum operating concentration, thereby realizing the maximum capacity of dry steam.

For the control of insoluble concentration, use of the continuous blowdown method should not be encouraged as, without proper conditioning of the feed water and definite control of the chemical reactions within the boiler, it does not provide protection against embrittlement, corrosion and scale formation.

Editor's Note: This is the first of several articles that will deal with new technic and new equipment in feed water conditioning.

Cheaper Power Through Modern Equipment

Boiler-room savings generally take one of two forms—increasing the boiler efficiency or burning a fuel that is less costly on a B.t.u. basis. A boiler efficiency of 70 per cent may not seem very high to the operator of a plant burning high-grade bituminous coal. Were such an operator suddenly presented with the problem of burning a 6,000-B.t.u. lignite containing 40 per cent moisture, he might congratulate himself if he was able to burn it at all, let alone attain 70 per cent efficiency. Low-grade fuels require modern equipment and operating methods, such as are used in the Washburn Station in North Dakota. An article next week will describe this plant.

LONGITUDINAL DISTRIBUTION OF STEAM

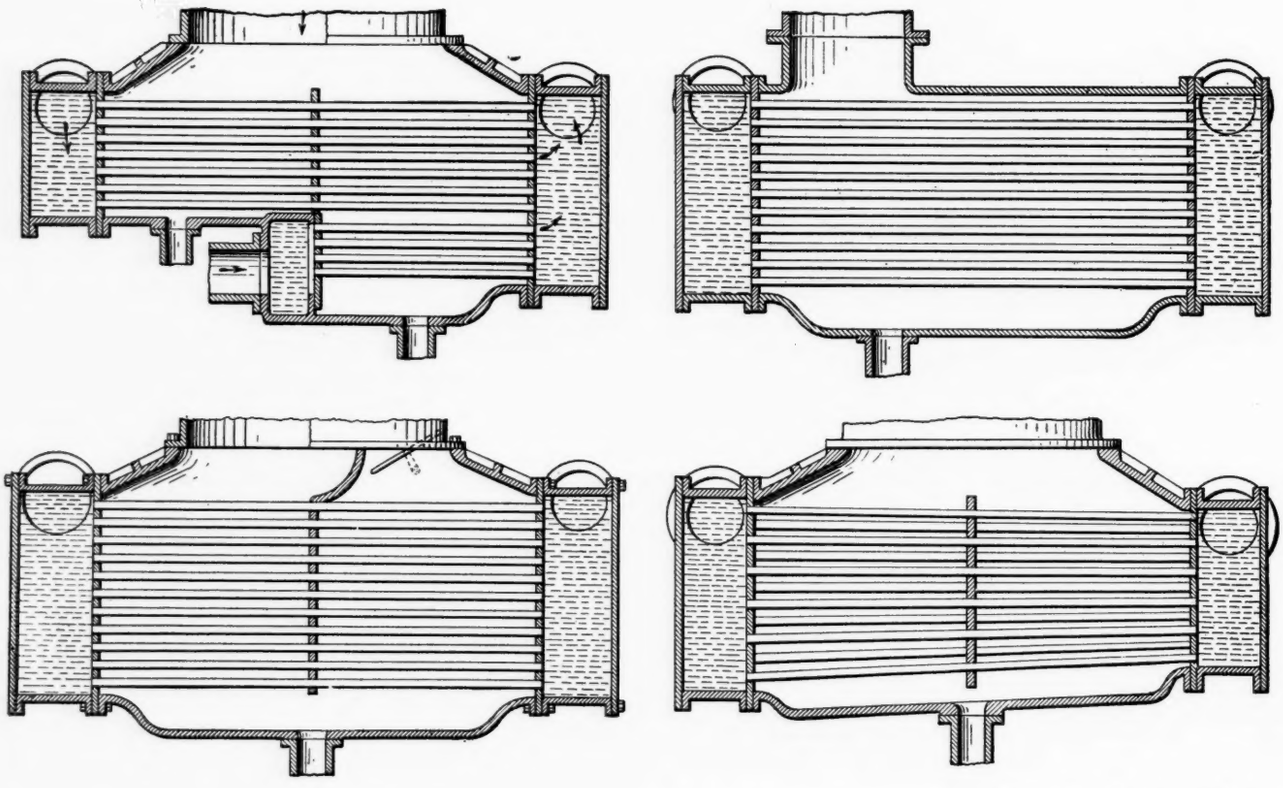


Fig. 1—Some condenser arrangements designed to improve the longitudinal distribution of steam

Improves Performance of SURFACE CONDENSERS

By Paul Bancel
Ingersoll Rand Company

TEXTBOOKS and the numerous articles on condensers in technical publications have almost invariably been confined to cross-sectional views of a condenser, neglecting entirely the problems of steam distribution arising in the longitudinal section. It is indeed curious that this feature of condenser design has been so much neglected in technical literature.

An article by Mr. Landis in the Nov. 13, 1928, number of *Power* attracted my attention to the 85,000-sq.ft. single-pass condenser serving the new 110,000-kw. unit at the Hudson Avenue Station. This condenser is subdivided into compartments by the tube-support sheets with independent steam-jet air removal for each compartment. As this is a feature of condenser design that the author developed and has advocated for a great many years, a brief elaboration of its necessity will be of interest.

The data given by Mr. Landis indicate that there is supplied 9.4 gal. of cooling water per tube at approximately seven feet per minute velocity. With reasonable assumptions of heat-transfer coefficient, steam at 28.5 in. vacuum or 91.7 deg. F. and inlet water at 70 deg., the discharge temperature would be 81 deg. The water is heated progressively along the tube and naturally comes out much hotter than it enters.

Considering the first foot or so of the tube, the temperature rise is slight and the mean temperature of the water is practically 70 deg. Therefore, the heat head

causing the flow of heat into the water is practically 21.7 deg. In the same way the mean temperature of the water in the last foot is practically 81 deg., and, similarly, the heat head 10.7 deg., or approximately one-half of what it was near the entrance of the tube.

If, now, you divide the 26-ft. tube into thirds, fourths or fifths, depending upon the number of support sheets

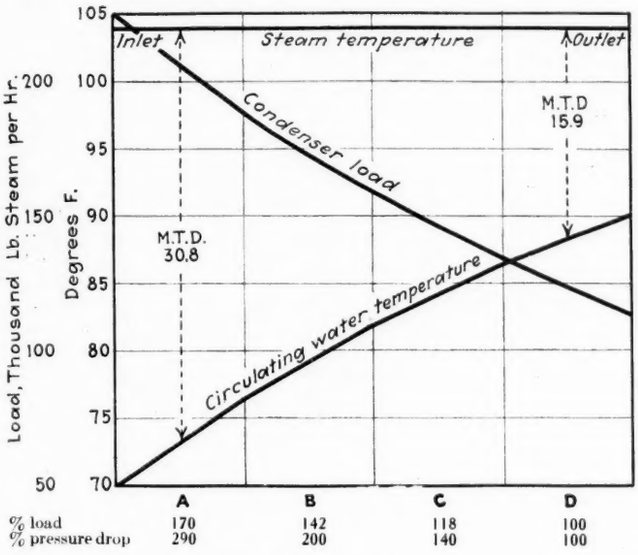


Fig. 2—Load distribution and temperature rise of circulating water with two pumps operating
Total load, 648,000 lb. of steam per hour.

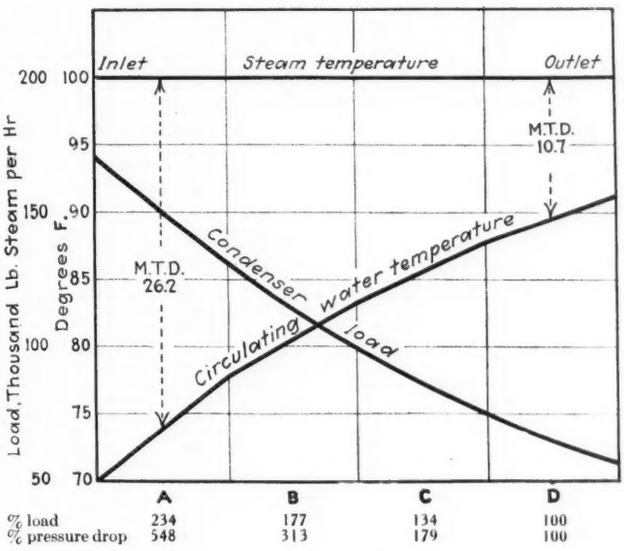


Fig. 3—Load distribution and temperature rise of circulating water with one pump operating
Total load 409,000 lb. of steam per hour.

put into the condenser, then it is evident that the compartment nearest the cold-water entrance has a larger steam-condensing capacity than the compartment near the exit. The entire condenser is, thus, really made up of a number of smaller condensers all working at the same vacuum, but with different circulating-water temperatures. In fact, the inlet end might be said to be working during May, while the outlet end is working during August. As more steam must go to the cold end, it follows that, to produce flow and penetration, the steam must be pushed harder, pulled harder or else a lower resistance provided.

Various solutions to the problem are illustrated in numerous patents issued to myself and associates. Considering the last solution first, larger flow area at the cold end may be obtained by arranging the condenser with wider tube spacing at this end or, inversely, closer tube spacing at the hot end. Another device is to decrease the depth of the tube bank instead of increasing the area, which means that the tube bank is made to contain more rows of tubes on the hot end than on the cold end.

In the second place, considering the method of pushing the steam harder, it is possible to offset the inlet so as to use the impact effect of the incoming steam to push harder on the cold end. Also, it is possible to subdivide the steam from the turbine so that it issues in a greater volume and at a slightly higher pressure at the cold end. In the latter case the extra pressure for the cold end is secured by throttling at the hot end with a damper. Fig. 1 illustrates the application of these principles.

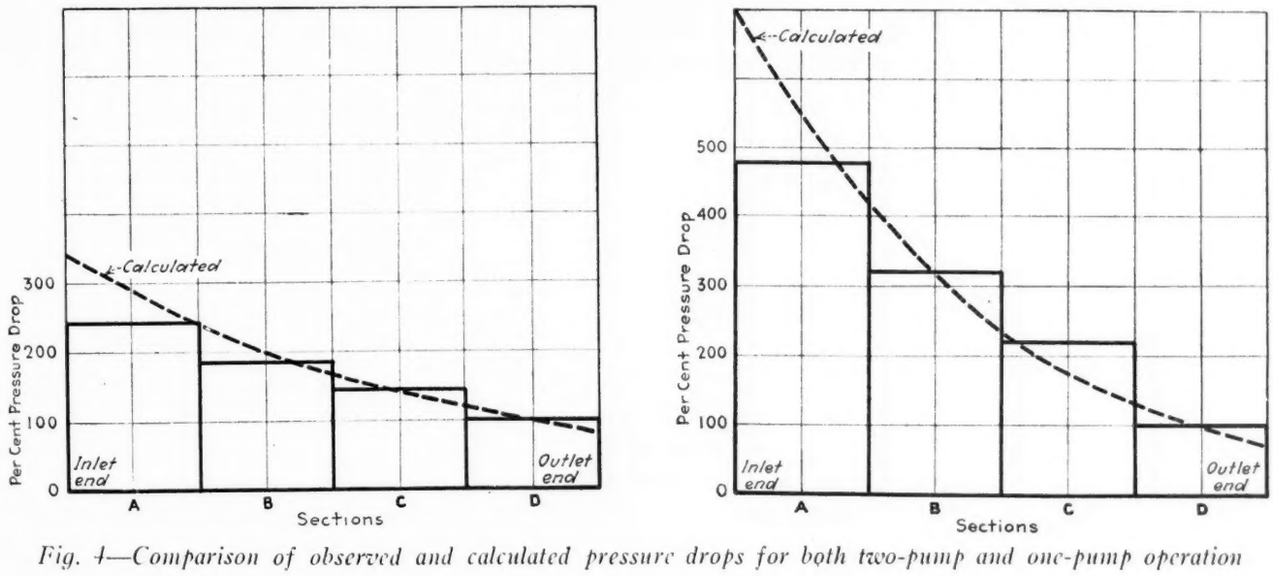


Fig. 4—Comparison of observed and calculated pressure drops for both two-pump and one-pump operation

These solutions seek the subdivision of the steam flow into two or more compartments according to some fixed ratio. However, the distribution ratio of steam volumes desired is not fixed. For example, if the circulating water is reduced, there is a greater range of heating

along the tube length and a greater discrepancy between the capacities of the first and last elements of surface. Figs. 2 and 3 are based on tests of a large four-compartment condenser operating with full water quantity (two pumps in operation) and with part quantity (one pump in operation). The change in relative condensing capacity is clearly shown. With the large water quantity the ratio of the steam condensed in the first compartment to that condensed in the fourth is 170 per cent, whereas with the smaller quantity the ratio is 234 per cent. Similarly, the pressure drop ratios (varying as the square of flow) are 290 per cent and 548 per cent respectively. Fig. 4 shows the calculated pressure drops compared to the actual drops observed. The change in relative pressure drops and flows is marked. It is evident that changes in water quantity do not affect the capacity of the compartments to the same extent, and therefore designs that fix definite ratios of flow areas, depth of tube bank and flow control by throttling, are more or less handicapped under varying operating conditions.

The capacity along the length of the condenser is also affected by the cleanliness of the tube. A tube scaled or fouled loses heat-transmission capacity, hence the water heats less for a given steam temperature, which tends to even out the steam distribution. If its heat transfer became zero, there would be no heating of the water at all and no problem in distribution.

It is, however, now known that tubes do not foul evenly along their length, but more rapidly at the hot end as compared to the cold. This has been demonstrated by actual heat transfer tests on single tubes removed from a condenser, the results of which are shown in Fig. 7. The coefficient of heat transmission along the length is approximately in the ratios 7.5, 6.3 and 5, being the poorest on the hot end. Figs. 5 and 6 show the steam distribution in a single-pass condenser when clean and when the tubes are fouled with the gradation of heat transfer shown in Fig. 7. The ratio of the steam-condensing capacities of the end compartments changes from 171 to 230 per cent, and the ratio of the pressure drops from 293 to 530 per cent.

The way in which tubes foul unevenly is also shown by practical observation. For example, with condensers using slime-forming waters it will be found that the hot end of a tube and the discharge tube sheet will be thickly coated with slime in contrast to the inlet tube sheet and inlet ends of the tubes, which will be almost perfectly clean. It is also a common observation in two-pass condensers (without lanes or bypasses) that the upper and hotter tubes are more rapidly slimed and scaled than the lower and colder tubes.

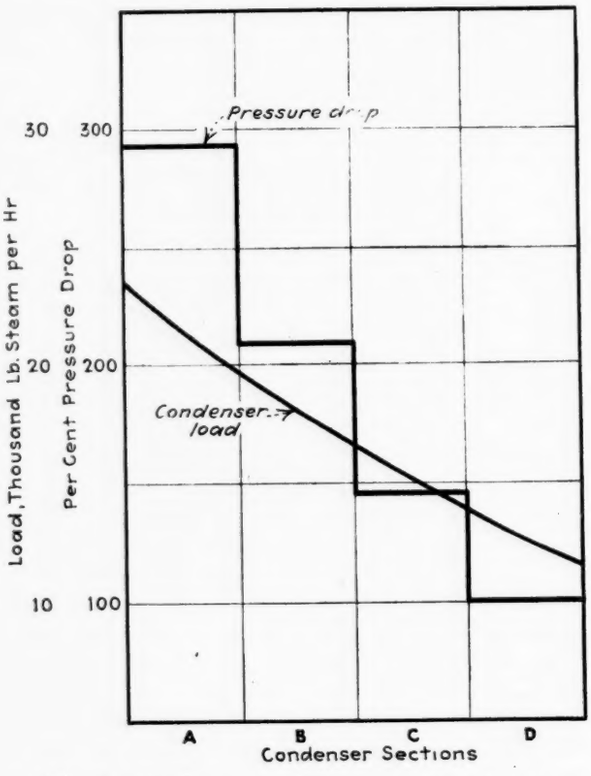


Fig. 5—Condenser performance with tubes clean and a total load of 67,000 lb. of steam per hour

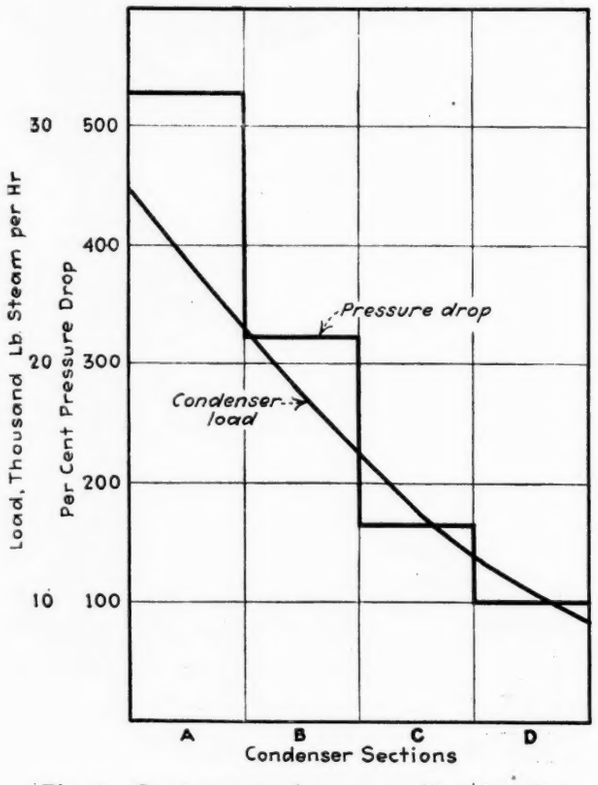


Fig. 6—Condenser performance with tubes dirty and with the same total load as in Fig. 5

A proper solution, therefore, of the problem of longitudinal distribution calls for flexibility and an automatic means of insuring complete steam penetration in all compartments along the length of the condenser under operating conditions. This is secured by having each compartment made tight and independent by the support sheets and withdrawing the air independently from each compartment. In such designs built by the Ingersoll-Rand Company, the air cooler and devaporizer is placed ahead of each vacuum pump, so that in a large unit, such as the 160,000-kw., 90,000-sq.ft. condenser being built for the New York Edison Company, there are four air coolers and four independent sets of primary jets, each serving one of four compartments along the longitudinal length of the condenser. The condensate is removed separately from each compartment and trapped to a common set of pumps.

It is sometimes thought that vacuums must be con-

trolled by hand or other means in order to secure the most efficient operation of each compartment. This is unnecessary because the steam jets automatically maintain the conditions desired in each compartment. They will remove air and vapor until a vacuum is reached that will cause enough steam to flow from the tube bank to choke the jets. When this occurs, any accumulation of air in the bottom of the condenser has been removed and an active steam flow is insured through the full depth of the tube bank. The point at which the steam will choke the jets occurs at a higher vacuum at the inlet section of the tube bank than at the discharge section.

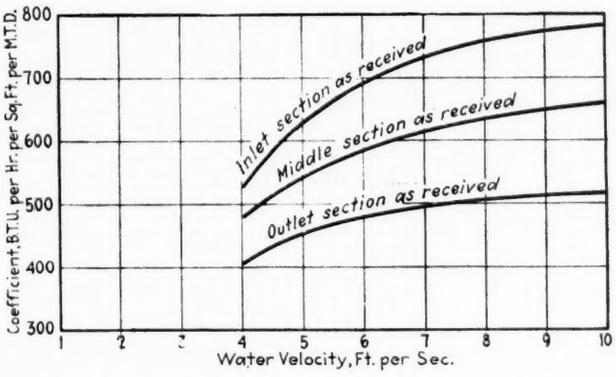


Fig. 7—Curves showing that the outlet section of a condenser fouls more than the inlet, and the effect on heat transmission

Fig. 8 shows the performance characteristic of a condenser operating with 70-deg. water and also the same condenser operating with 80-deg. water. The absolute pressure at the bottom of the condenser is shown by a dotted line for both conditions of operation through the range of loads. It will be noted that when maintaining 2-in. pressure with 70-deg. water, the pressure at the bottom of the condenser is 1.8 in., whereas with 80-deg. water it is 1.9 in. In the first case there is 0.2-in. pressure drop and in the second case there is a 0.1-in. pressure drop. The action of the vacuum pump is automatic, always maintaining the highest vacuum that it can at the bottom of the condenser.

If the conditions are compared to a single condenser working with 70-deg. water at its inlet end and approximately 80-deg. water at its outlet end, it will be seen that the steam jet connecting to the inlet compartment will automatically pull a higher vacuum because more steam can be condensed in this section, just as happened in the foregoing example of the same condenser working with 70- and 80-deg. water. If the compartments were not separated and only 0.1 in. pressure drop was available for the cold end, then it is obvious that the steam would not be able to penetrate into this compartment to the full depth. There would be a partial penetration represented by the difference between the pressure drops of 0.2 in. and 0.1 in.

It is also evident that there is automatic control of the penetration in each compartment for any changing condition such as the amount of circulating water or cleanliness of the tubes. Each compartment functions independently of the conditions in the others. The small pressure drop and tendency for short circuits in the hot end cannot affect the vapor and air removal from the cold ends.

Longitudinal control of the steam is important not only in large condensers, but also in small units and in multiple-pass condensers as well as single-pass. In small units the length is still relatively long, and with tube diameters of $\frac{5}{8}$ in., $\frac{3}{4}$ in. and in some cases $\frac{7}{8}$ in. there is still a large difference in thermal capacity along the length. However, it is cumbersome and complicated to use multiple-vacuum pumps, and small condensers are built with a single air cooler and vacuum pump, but with permanent throttle plates at the outlet of the compartments toward the hot end. In these condensers there is usually a circular exhaust covering only a fraction of the condenser length, causing an impact effect concentrated in the center. This impact effect is counteracted by suitable throttling, either at the vapor outlet of the central compartment or by arrangements within the tube bank where the spacing is offset in the support sheet, thus bringing the tubes together and offering a greater resistance to flow.

A two-pass water circuit tends to balance some of the unequal distribution, but only in part. A two-pass condenser is simply two single-pass condensers superimposed, and calculation shows that there must be a difference in flow and a considerable difference in pressure drop at one end as compared to the other. This is further exaggerated when it is considered that the top pass scales or slimes more than the bottom pass, under which condition there is a tendency for a bad short circuit through one end.

To illustrate the importance of longitudinal distribution of steam the devices for controlling the flow at the inlet of a moderate-sized condenser were removed and the vacuums equalized as in a condenser without provision for flow control. The performance of the condenser was greatly impaired. The large regions of inactive surface at the bottom of the tube bank, resulting from uncontrolled flow, more than doubled the condensate depression. There was serious drop in vacuum, and the over-all coefficient of heat transmission was reduced by a large percentage.

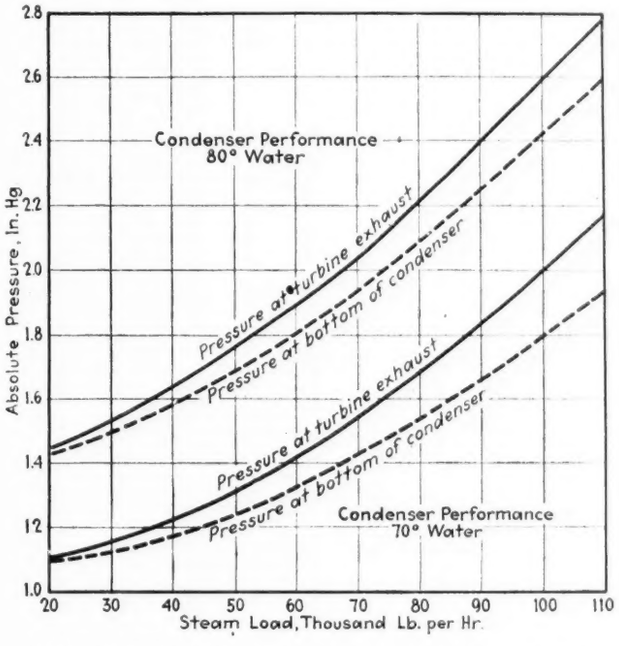


Fig. 8—Comparison of pressure drop through the condenser when operating with 70- and 80-deg. circulating water

FOURTH MID-WEST

. . . PRESENTS

THE four-day meeting of the Mid-West Power Engineering Conference held at the Palmer House, Chicago, drew an attendance of over 1,500. There were six sessions, supplemented by three noonday luncheon meetings, and inspection trips were made to a large number of plants. The banquet and ball was a big feature, with an attendance exceeding one thousand, and Dr. Walter Dill Scott, president of Northwestern University, was the speaker of the evening, his topic being "The Influence of Mechanical Power on Human Nature."

Officially opening the Conference at a luncheon Tuesday noon, President W. L. Abbott stated that the present convention, like all others, had met to discuss the changes of the year. American engineers had learned that free interchange of ideas was the basis of all advance in engineering. The more information given, the greater the progress and prosperity that would follow. America's pre-eminence in power was due fundamentally to her fuel resources, and while immense strides had been made in efficiency, so that scarcely half as much coal was now required to develop a unit of power as was needed twenty years ago, still greater economies were necessary to conserve the heritage of fuel resources for the benefit of posterity.

Power-plant substructures, metals for power plants, corrosion, heating and ventilating research, applications of refrigeration, steam turbine and stoker development, 1200-lb. pressure as a dollar saver, co-ordination of industrial and central-station power, new centrifugal pump theory, X-ray testing, welding, and engineering insurance were some of the topics discussed at the six sessions.

Papers supplied by the civil engineering contingent dealt with the design and construction of the stream-flow hydro-electric plant at the falls of the Ohio, near Louisville, and the design and construction of steam power-plant substructures.

H. G. Roby, of the Byllesby Engineering & Management Corporation, gave the details of design and construction of the 80,000-kw. hydro plant recently erected on the Ohio River near Louisville. The plant has eight units, operating under a maximum head of 37 ft. and requiring in total at full gate opening a water quantity of 31,000 sec.-ft. Features of the plant are the use of propeller type, high-speed runners, permitting operation on heads ranging from 7½ to 37 ft., automatic control from a supervisory board, and specially designed systems for handling and supplying bearing and governor oil. Full details of the plant appeared in the Feb. 7, 1928, number of *Power* and a description of the methods of handling oil in the Aug. 28 number.

According to J. C. Sanderson, of Sargent & Lundy, in his paper on "Power Plant Substructure Problems," the difficulties of power plant foundations are not so much devising means of supporting heavy loads on unsatisfactory soils as in avoiding unequal settlements between the various parts of the building, which might mean a broken steam or water line or a high-speed machine out of level. To illustrate some of the diverse conditions that may be encountered, the author had selected for consideration the foundations of four power plants recently built. The first is in Mexico City on a soil of low bearing capacity where it was not practical to use piles on account of the earth's getting softer with the depth, it being one thousand feet or more to hardpan. The foundation was designed as a light concrete barge with longitudinal and transverse steel trusses which took up the entire basement story.

Powerton station, on the Illinois River near Pekin, was taken as an example of a plant built on water-bearing sand which required in the construction of the foundation a special cofferdam, the bottom of the condenser pit being 25 ft. below the high-water level of the river. As the boiler-room foundations were in sand over 20 ft. above the bottom of the condenser pit, unusual methods of construction were required and a detailed account of the various construction operations, by the author aroused interest.

The third case cited was a deep foundation on water-bearing gravel, that of Columbia station, on the Ohio River, where the variation between low and high water is 64 ft. Here most of the piers were dredged down, as was the condenser pit. Hollow prepoured piers were sunk in twelve-foot sections by dredging the material from the inside. When the pier reached gravel, the concrete seal was poured through the water and a cap put on the top, leaving the hollow pier partly filled with water.

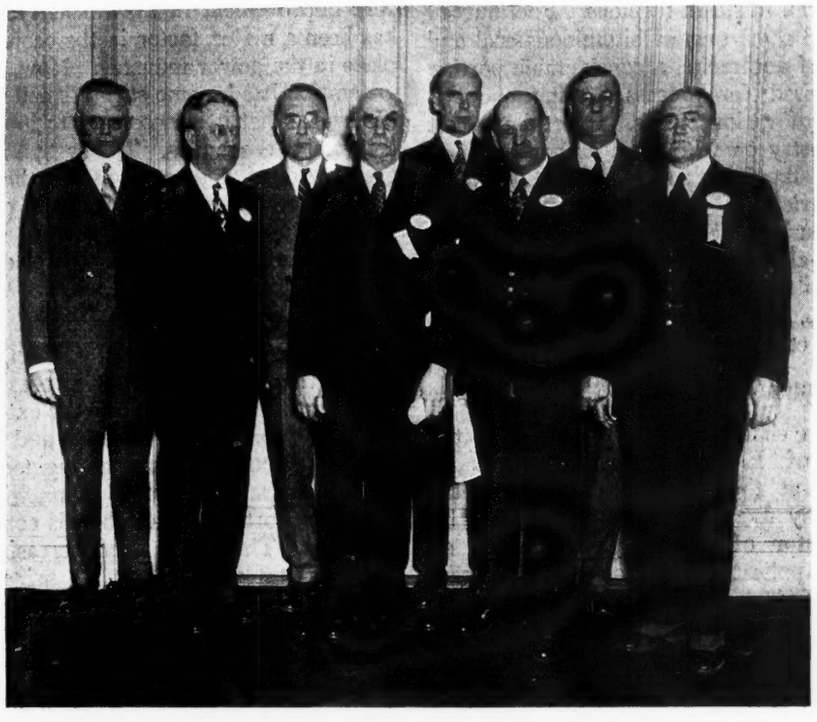
Crawford Avenue plant of the Commonwealth Edison Company, Chicago, was the fourth example. The soil was a blue clay increasing in hardness with the depth to hardpan, which was encountered 25 to 30 ft. below grade. Building walls and columns were carried on caissons founded on hardpan and sunk by the Chicago well method. Turbine foundations were mat footings on the clay, made strong enough so that the entire foundation for a machine would stay in one plane. With this design a slight settlement, even though out of level, would cause no trouble. Piping connections were made suffi-

POWER CONFERENCE

VALUABLE PROGRAM

ciently flexible to accommodate a slight change in elevation. Following on the same subject, P. E. Stevens, of the Byllesby Engineering & Management Corporation, had selected a number of typical cases from the construction records of the company, giving a wide variety of conditions encountered and the methods by which they were met.

At the Wednesday morning session, sponsored by the American Institute of Mining and Metallurgical Engineers, three papers were presented, all having the power-plant slant, as had been arranged when planning the program.



Prominent participants in Fourth Mid-West Power Engineering Conference

Left to right, front row—L. R. Howson, chairman opening session; W. L. Abbott, president of the conference; H. M. Raymond, president of Armour Institute of Technology; C. C. Whittier, chairman of reception committee. Back row—P. E. Stevens, author of paper; W. S. Monroe, president of Sargent & Lundy; H. G. Roby, author of paper; J. C. Sanderson, author of paper.

Metals in Power Plants

A comprehensive summary, touching the high spots in the broad subject of metallurgy as applied to power plants, was presented by Prof. A. E. White, of the University of Michigan. The paper was divided into two sections; one concerned the metals used in this field, together with special processes for producing certain desired results, while the other considered the tests applied to metals to determine their suitability for the various required applications. A full abstract of this paper will appear later in *Power*.

A few of the more salient features of the corrosion problem, as it relates both to the inside and the outside of the power plant, were touched upon by H. S. Rawdon and K. H. Logan, metallurgist and electrical engineer, respectively, of the Bureau of Standards. Within the plant the most serious corrosion problems arise in connection with the generation and use of steam. Corrosion by steam and by water, the effects of oxygen and carbon dioxide, the influence of the character of the metal and its treatment in the erection of the installation, and the causes of "embrittlement" were some of the factors given consideration. Attention was given also to corrosion from furnace combustion products, usually attributed to impurities in the fuel, such as sulphur, and limited largely to the cooler portions of the furnace systems, where condensation may take place.

Without the plant, corrosion problems are as varied and difficult as those within. Reference was made to

the attack on overhead transmission lines and towers by corrosive vapors; the acceleration of the corrosion of copper when the atmosphere contains ammonia, salt as encountered along the sea coast, or large quantities of smoke as at railway crossings; the substitution of aluminum for copper; the coating of towers and guy wires with zinc, and the action of soils on galvanized and black steel. A number of corrosion troubles encountered in underground power lines were cited and mention was made of the failure of reinforced concrete, owing to the rusting of the reinforcement.

Use of Power in Chemical Industries

Charles M. A. Stine, chemical director, E. I. duPont de Nemours & Co., gave some interesting statistics indicating that the chemical industry as a whole is a large user of power and steam. In the 6,710 chemical and closely allied manufacturing plants that supplied data for the 1927 Manufacturers' Census, the power-generating equipment installed aggregated 2,802,388 hp. From the primary power classification, 706,022 hp. was in steam engines and 793,784 hp. in steam turbines. Fuel burned aggregated 87,724,883 short tons of bituminous coal and 2,150,019 long tons of anthracite, a considerable portion of this fuel being used for process heating and for operating equipment of various types. Other important branches of the industry on which the author dwelt at some length were the fixation of nitrogen, the liquid-air industry with its variety of products and their uses, production of solid carbon dioxide as a refrigerant, the electrochemical and electrometallurgical industries dependent largely on water power and consuming approximately 1,250,000 hp., the paper and pulp industries, petroleum refineries, etc.

Electrical Engineering

Papers electrical in character and sponsored by the American Institute of Electrical Engineers had an auspicious beginning at the luncheon on Wednesday, which was attended by five hundred and addressed by G. L. Clark, professor of chemistry, University of Illinois, on "X-Ray Applications in Everyday Engineering Problems." Defining the ray as identical with ordinary visible light except that the wave lengths were only 0.0001 as great, on the average, the author brought out in a most interesting manner the innumerable uses to which these versatile rays are being put by the medical practitioner, the biologist and botanist, the physicist to explore the interior of atoms, the chemist in discovering new elements, and now industry to solve some of the most difficult problems of producing commodities of certain and satisfactory quality. In the engineering field some of the radiographic applications are the examination of metal castings for imperfections and degree of heat treating, of welds for soundness, of coal for slate and ash, of minerals for classification and of a long list of non-metallic materials for various purposes.

At the session following the luncheon C. E. Stewart, of the General Electric Company, described one of the latest types of automatic supervisory equipments, its application to electrical power supervision and its functioning with automatic telemetering equipment. Use of such equipment, he said, gives the dispatcher of a power system load a continuous picture of the power-circuit conditions, and provides him with means for controlling them.

Trends of development in electricity supply systems, including the more important phases of generation and distribution, were pointed out by W. F. Sims, of the Commonwealth Edison Company. Reference was made to the unit section idea of plant layout, simplification of automatic and remotely controlled equipment and the establishment of a commercial balance between thermal efficiency and fixed charges. Trends in the boiler room, such as larger units, tendencies in pulverized fuel, higher steam pressures and temperatures, water-cooled surface and automatic combustion control, were touched upon. In the turbine room, Mr. Sims said, the switching problems created by the use of large generators are being relieved by higher-voltage machines or by the use of the two-winding generator.

Summarizing the governing factors of the future trend, the author quoted from an article by E. C. Stone to the following effect. Looking forward to future conditions, emphasis is being placed on the necessity of more system capacity per dollar of investment because of the increasingly important part that fixed charges are playing in the total cost of electric power service. Heretofore improvement in the efficiency of fuel consumption has been a major factor in the economics that had taken place in the power industry. Now, however, the cost of generation has become such a small part of the total cost of service that it is necessary to look elsewhere for further major economies. The system investment offers the great field of opportunity. In the past, attention has been centered in reducing fuel and other operating costs. In the future it will be devoted particularly to economical system design and control of construction costs.

Heating, Ventilation and Refrigeration

To these subjects a full session, with three papers, was devoted to the newer phases of ventilating and refrigerating practices and to the extensive research work now being conducted on heating and ventilating problems.

S. C. Bloom, consulting engineer, Chicago, showed how refrigeration in combination with ventilation, as an aid to comfort in hot weather, is contributing to national efficiency. Theaters in ever-increasing numbers, he said, are adopting cooling systems using refrigeration with successful results, and to provide a comfortable environment, department stores, restaurants and hotels are following the same practice. Similar cooling of office buildings presents a field of tremendous potential value. At present several large office buildings are being planned or under construction that will be cooled throughout.

To cool the water which in turn cools and purifies the air, requires a varying amount of refrigeration, depending upon temperatures and the relative proportion of recirculated air. Current practice is to recirculate from the building and recool 50 to 75 per cent of the air supplied, so that refrigeration at the rate of 2½ tons per day per 1,000 cu.ft. per min. air supply is fairly representative. The volume of cooled air introduced usually is sufficient to change the air of a building completely five to eight times per hour.

To maintain satisfactory conditions recent tendencies are to work toward higher room temperatures and lower humidity. For example, early requirements are for a condition of 70 deg. F. and 50 per cent relative humidity indoors, with hottest summer weather outside. The contrast proved unbearable, so today a condition of 80 deg. F., with a relative humidity of 55 per cent, is considered quite satisfactory when it is 95 deg. outdoors.

A. J. Authenrieth, vice-president in charge of ice and

refrigeration, Middle West Utilities System, in an interesting paper, showed how the application of refrigeration to perishables has brought about a marked betterment in the standards of living throughout the country and has made possible the agricultural development of sections that otherwise would lie as wasted, useless land.

On the score of power development, refrigeration and ice-making has grown into an industry that is proving to be one of the largest consumers of power. Census figures of 1927 placed the total cold-storage space in the United States in both private and public plants at 731,377,000 cu.ft. On the basis of a nominal rate of 60 kw.-hr. consumed per 1,000 cu.ft. per month, the power for cold storage amounted to 526,591,440 kw.-hr. per year. Assuming 59 per cent electrified, the yearly electrical consumption was 310,688,600 kilowatt-hours.

Of the total number of ice plants in this country (over 7,000) about 32 per cent are steam driven, 59 per cent electric driven, and 9 per cent gas and oil driven. Using an average figure of 62 kw.-hr. consumed per ton of ice made, the electric power used by ice plants last year totaled 2,232,000,000 kilowatt-hour.

Research in Heating and Ventilation

Research as applied to heating and ventilating and centering originally in the research laboratory of the American Society of Heating and Ventilating Engineers, was reviewed in outline by Samuel R. Lewis, consulting engineer, Chicago. Founded in 1919 in collaboration with the Bureau of Mines experiment station in Pittsburgh, the work grew so rapidly that it became necessary to raise the dues of the Society 66⅔ per cent and devote two-fifths of the receipts to the laboratory. Expansion of the work to be done continued, so that the budget for 1928 was double the income from member dues, and the balance was contributed by friends of the industry.

Activities of the laboratory were directed toward research in fields not likely to be covered by immediate commercial results, and which therefore tended to lag behind the developments and inventions emanating from the research of the larger manufacturers. Thus, among other things the laboratory had studied intensively air filtration through walls, heat conductivity of structural materials, effect of paint on radiating surfaces, carrying capacity of pipes, and the physiological influence of different ventilating and temperature conditions on the human body.

In 1927 a co-operative arrangement was made with the University of Wisconsin whereby research would be carried on at Madison under the general technical direction and approval of the Society and under a joint expense account. Later, similar co-operative agreements were made with the University of Minnesota, University of Kentucky, Purdue University, Harvard University, Texas Agricultural and Mechanical College, Carnegie Institute of Technology, the United States Weather Bureau and the health departments of thirteen representative cities. Further extensions are imminent, but delayed by the financial budget.

Power-Plant Problems

On Thursday a luncheon under the auspices of the Western Society of Engineers featured certain recent developments in the steam turbine, R. C. Allen, of the Westinghouse Electric & Manufacturing Company, being the speaker. The session following and the final meeting on Friday morning, both sponsored by the mechanical engineering group of the Conference, dealt with certain phases of power-plant operation, economics and design.

Mr. Allen emphasized the importance of the time element in improving the construction of steam turbines. Commercial pressure has made it necessary to build the largest machines in a year or less. To do this a large engineering department is necessary, and this outside pressure increase its creativeness and productivity. The time element entered again with the greater number of units installed in a given period and the vast amount of operating data made available. Other factors advancing development, the author stated, are the pride of accomplishment and the progress made through accidents. Partnership between the turbine builder and the operating company is essential, as the large machines can be operated and tested only in the plant.

The general trend of turbine design has been toward reliability and simplicity. Improved designs and better materials have permitted higher blade speeds, which have resulted in greatly reduced weights and reduction in the size and cost of the turbine. Construction features of some of the larger turbines recently installed were shown in lantern slides.

Centrifugal Pump Economics

Prof. A. F. Scherzer, of the University of Michigan, in a paper on "Centrifugal Pump Economics," had the surprising message for the Conference that the commonly accepted theory of the centrifugal pump is in error. The wide discrepancy between the theoretical quantity-head curve and the actual curve obtained by test, between which there was a difference of approximately 100 per cent at or near the shutoff point, indicates a serious misconception not only of the action of the centrifugal pump, but of one of the fundamental laws of hydraulics, the error being due to a misapplication of the Bernoulli theorem.

Near the shutoff point the head actually obtained from a pump is approximately $V_2^2 \div 2g$, whereas the head called for by present pump theories is about $V_2^2 \div g$, or nearly twice as much. This difference is explained and accounted for by different authorities in various ways, as for example shock losses, none of which appear probable or convincing, and further do not meet certain requirements of fact.

When water flows in a pipe, according to the author, it is customary to say that the total head is obtained by measuring the pressure head by a piezometer at right angles to the flow, and adding the velocity head. This is a correct application of the Bernoulli theorem. The pressure and velocity exist as separate and distinct factors. However, with water set in rotation in a cylindrical vessel by the action of a paddle or impeller, there is pressure created by centrifugal force equal to $V_2^2 \div 2g$, which is part and parcel of the velocity itself. The total head might be regarded as either, but not both, for the reason that the energy imparted is only $V_2^2 \div 2g$, and naturally the water could have no more energy than it was given by the impeller. One reason the author advanced for the cause of this common error in pump theory is the widespread failure to distinguish properly between pressure and energy.

Other practice founded on a misconception of theory is the use and benefits to be derived from guide vanes or diffusor vanes. In a centrifugal pump it is wrong to assume that the total energy is represented by the pressure in the casing plus the kinetic energy of the abso-

lute velocity of discharge. As the water is confined to a circular path, its kinetic energy is necessarily converted into pressure without any assistance from the guide vanes. In fact, they often serve to obstruct the natural flow of water, which entirely defeats their purpose and renders them useless. What has been said about guide vanes also might be extended to include the so-called volute or spiral casing into which the runner discharges the water.

Having explained the fallacy in the use of guide vanes and volutes or spiral casings, the author stated that the real function of the pump case is that of compelling the water to revolve in a more or less circular path, whereby the pressure is developed in much the same way that a stone whirled at the end of a string develops tension in it. From this it appears that the natural form of a case is not a volute or spiral, but rather a plain concentric circular case of constant cross-sectional area.

Reviewing simply the elementary action of the centrifugal pump to expound his new theory, the author led up to the statement that the entire problem of the centrifugal pump is that of flow through three orifices in series. The first is at the suction entrance to the impeller; and this determines the maximum capacity of the pump. The second is at the discharge from the runner, and the third at the throat of the pump. Each of these orifices or points of restriction has its own characteristics and their combined effect determines the pump characteristic.

Points made in the discussion of this paper indicated the need in the high-pressure pump field for improved mechanical construction, better materials and suitable provisions for expansion. For boiler feed dependance cannot be placed on one pump. For medium-sized units there is need for two or three, and for more on the larger units. Pumps of the new Scherzer design have been built, have withstood the tests of service, and are performing according to theory. Questioned as to a rising characteristic, the author explained that any characteristic curve could be obtained by adjusting the size and shape of the three orifices; that is, of the pump throat and the water passages.

Co-ordinating Industrial and Purchased Power

Co-ordination of industrial and central-station power was a subject treated by R. J. Gaudy, of the Sessions Engineering Company. As a case in point the author cited the Packard rehabilitation program, involving co-ordination of generated and purchased current, the balancing of power and heating demands, and other features described in the Nov. 27 and Dec. 4 1928, number of *Power*.

He stated that industrial power could not be generated under usual conditions with economy to the industrial unless the central-station rates were inordinately high, the supply inadequate or irresponsible, or other special conditions prevailed.

Fundamental economy demanded more attention to interconnection between the industrial and the central station. Concurrence of responsibility and demand and relative load factors, however, had as great a bearing on justified interconnection as the most attractive set-up for recovery of byproduct fuel or energy.

Welding of Power-Plant Piping

In a paper on this subject F. G. Outcalt, development engineer of the Linde Air Products Company, summarized the many advantages of welding and proceeded to show that developments during recent years has reached the point where it is possible for the power-plant engineer to treat welded construction exactly as he did other types. To secure high-quality results the steps taken were: Exact specifications of materials and design, selection of a competent organization to do the work, and provisions for inspection to see that the specification had been carried out.

To make sure that the designs were followed correctly during fabrication and installation, the author gave a sample qualification test for the welders who were to do the work and outlined the procedures for leakproof, tensile and ductility tests, with a final word on inspection and test of the work.

1,200-Lb. Pressure as a Dollar Saver

One of the most interesting papers of the conference was that by Edwin Jowett, dealing with the recent 1,400-lb. boiler and 1,200-lb. turbine installation at Northeast Station of the Kansas City Power & Light Company. Two 17,000-sq.ft. bent-tube boilers burning pulverized coal and provided with economizers and air preheaters, supply a 10,000-kw. turbine-generator which exhausts through reheaters in each boiler to the 300-lb. station header, steam conditions at the throttle being 1,200 lb. and 725 deg. F. This unit supplements the previous installations operating at 300 lb. pressure, consisting of three 23,000-kw. and two 30,000-kw. turbines served by twelve 13,500-sq.ft. boilers. Estimates had been made that the heat consumption of the station would be lowered from 16,800 to a composite net average of 14,970 B.t.u. per kw.-hr. by the operation of the high-pressure equipment. A full abstract of this appeared in the Feb. 19 number of *Power*.

Engineering Insurance

J. P. Morrison, chief inspector, Hartford Steam Boiler Inspection & Insurance Company, gave an instructive talk on engineering insurance, reviewing its development from the speculative ventures by visitors to Lloyd's Coffee House in London to the underwriting practice of the present day. The first organized effort to develop a legalized form of insurance protection against loss resulting from the perils of steam-boiler operation was made at Manchester, England, in 1859. Following the paper an interesting collection of lantern slides was presented to show typical accidents to power-plant equipment and defects discovered in time to avoid accidents, including inspection methods used in the discovery of steams affected by embrittlement.

Modern Stoker Equipment

G. U. Moran and C. F. Hirshfeld, both of the Detroit Edison Company, reviewed the development of stoker firing for steam generation, giving special attention to the present status of the forced-draft chain grate and the multiple-retort underfeed stoker.

Advance of the mechanical stoker had been affected greatly by certain outside influences. The increase in size of generating units led naturally to larger stoker and boiler sizes. Then refractories began to show weaknesses that resulted in the development of water-cooled walls. The use of preheated air followd closely on the water wall, as furnace temperatures were again on the upward trend. These factors opened up more possibilities for the stoker and the advance had been steady since their introduction.

Preheated air the authors stated, is being used exten-

sively where furnaces are water or steam cooled. The present limit of preheat seems to be about 300 to 350 deg. F., although some stoker manufacturers advocate as high as 550 to 600 deg. F. Notable progress has been made in the fuel-burning capacity of stokers, both because of increased dimensions and through increase in the unit capacity of the grate. The increase in dimensions has occurred both longitudinally and laterally, with most of the rise in fuel burning due to the increased lengths. In the case of the chain grate, the increases in length and width have brought serious design and mechanical problems, while the multiple-retort stoker has lent itself easily to an increase in width, although its extension longitudinally has been attended with some difficulty.

Progress of the mechanical stoker from 1915 to date was shown by curves derived from manufacturers' statements and test data from installations supplemented by two stokers that had not been constructed as yet. Several cuts of modern installations illustrated the various factors that have influenced stoker and furnace design. The authors stressed the advisability of being generous when choosing stoker auxiliaries such as motors and fans, both as to size or capacity and refinement of adjustment. The use of direct- and alternating-current drive was discussed. Direct curent is the more flexible but costly. When lacking in flexibility alternating-current is less expensive, but when the alternating-current drive approached the flexibility of direct current, it becomes complicated and its cost approaches that of direct current.

The authors believed that no system of automatic combustion control at present was capable of exceeding the results of conscientious and skillful operators, but this should not be construed to mean that automatic control had no place with the automatic stoker. The degree to which it was used should be governed by local conditions such as cost of fuel and labor, size of unit, etc.

Electricity Defined?

AT LAST a satisfactory(?) definition for electricity has been found by the New York State Committee on Public Utility Information. Its *Utility Bulletin* of Jan. 28, says:

Electricity is something that starts the Lord knows where and ends in the same place. It is 1/36 of a second faster on its feet than its nearest competitor, backyard gossip, and when turned loose in Europe will get to the United States five hours before it starts. Nobody knows exactly what it is because it has never stood still long enough.

Electricity is sometimes known as science gone crazy with the heat, and if you can understand its maneuvres, you can do anything with it except open a can of peanut butter at a picnic.

Electricity was locked up in ignorance for centuries until Ben Franklin let it out with a pass key, and since then it has been pulling off more new stunts than a pet monkey.

With it you can start a conversation or stop one permanently, cook dinner, curl your hair, press your trousers, blow up a battleship, run an automobile or signal Mars, and many more things are being invented.

Acknowledgment

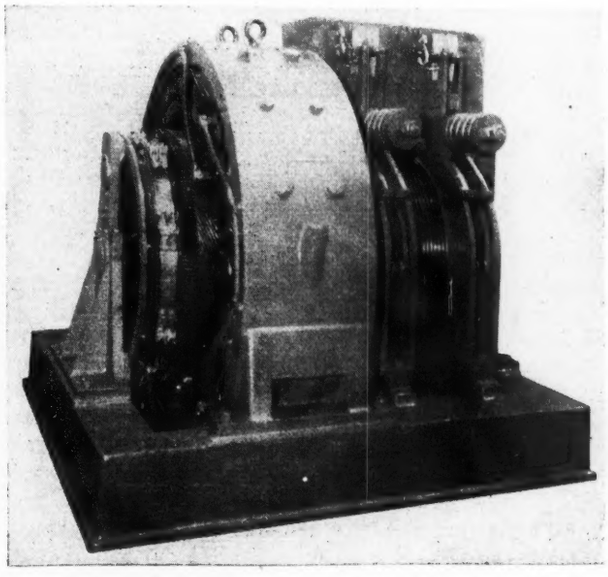
The authors of the article on "Drives for Forced and Induced Draft Fans," Jan. 22 number, advise that through an oversight they neglected to give credit to A. Kolflaath, of Sargent & Lundy, for the analysis of motor torques plotted in Fig. 5.

Traction Elevator Motor Used on Mine-Hoisting Equipment

By H. W. Chadbourne
Industrial Engineering Department, General Electric Company

A MINE hoisting equipment that utilizes a gearless traction-type elevator motor has been installed by the Phelps Dodge Corporation at Morenci, Arizona. This is the first time such equipment has been applied to a mine hoist, the usual application being on passenger elevators in large buildings.

The motor has eight poles and is rated 140 hp. at 85 r.p.m. and 250 volts. The motor and the hoisting drum are built as one unit, which is considerably simpler than the usual hoisting equipment. The traction motor



Gearless traction-type elevator machine with a U-grooved sheave

is mounted in the head frame over the hoistway, thus eliminating the drum on the ground level. This motor, incidentally, is the largest of its type built for any service. Six $\frac{3}{4}$-in. cables are used, roped two-to-one. A U-grooved traction sheave with a secondary sheave is used, making a full-wrap roping on the traction sheave. The two-to-one roping gives a car speed one-half that of the rope and the load on the ropes is approximately one-half that for the one-to-one system of roping.

A mixed-duty service is required of this installation. The mine shaft is 800 ft. deep, and the hoist, operating at a car speed of 400 ft. per min., will carry men into and out of the mine, will take supplies to the various levels of the mine, and will handle ore.

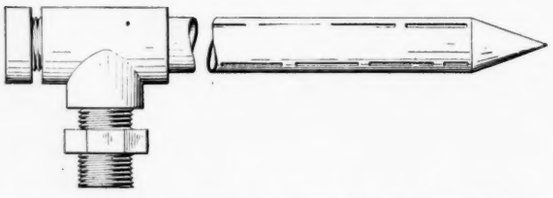
Besides the simplification of equipment there is a further advantage in the use of this type of hoisting motor, as standard variable-voltage control may be used, which is more accurate than the usual mine-hoist control. The control panel and motor-generator set are mounted in the hoisthouse at ground level. Normally, the hoist will be controlled by an operator in the cage, but a master switch is provided in the hoisthouse for emergency use. The two control stations are so interlocked that operation can be governed from but one at any time.

Right Out of the Plant

Extinguishing Fires in Coal Piles

MY FIRST experience with a coal-pile fire showed me that throwing water on the pile had little effect on the fire within it. If the water is to extinguish the fire, it must be forced directly into it, instead of being baffled away from it by a volume of vapor and gas that develops when the water trickles into the heated zone from the outside.

We took a piece of 2½-in. pipe, twelve feet long, pointed at one end and screwed a tee on the other. A capped nipple was screwed into the other end of the tee



Pointed pipe nozzle is pushed through coal pile to location of fire

and the side outlet served as a hose connection. The pipe was slotted from the point for about five feet. The slots were made one-eighth inch wide and about six inches long. Short bridges of metal were left between them to give strength and hold the shape of the pipe, as shown in the illustration. When the coal was found gassing or burning, this pipe was forced through the pile into the fire, the hose connected and water turned on. With this device we have stopped gassing of coal piles and put out fires in a short time with little water.

It is some time since we have had trouble with coal-pile fires. The reason for this is we buy coal that can be safely stored. It is piled on concrete platforms along our switch tracks. If a car of dirty coal comes in, we use it at once or place it where it can be moved readily with the crane.

W. L. PARKER.

Elgin, Ill.

Interlocking Control System for Conveyors

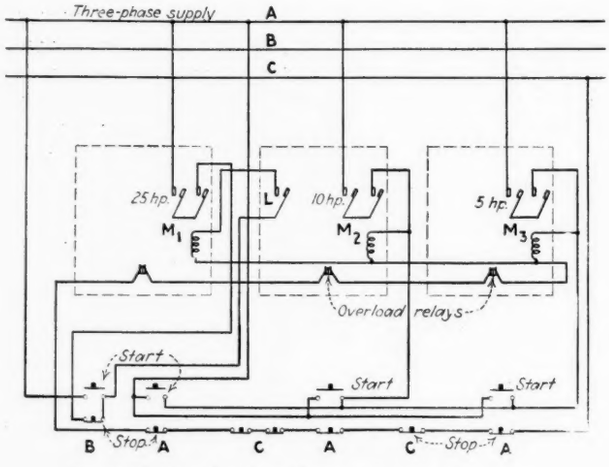
IT WAS recently necessary to work out a method for the control of three motors driving a conveyor system. The user had a 25-, a 10-, and a 5-hp. motor, and wished to start the 5- and 10-hp. machines simultaneously. It was also desired to have the control laid out so that the 25-hp. motor could not be started until the other two were running. The system was to be interlocked so that overload on any one of the three motors would shut down all three. Further, the 25-hp. motor was to be started and stopped independently of the other two, provided the 5- and 10-hp. motors were running. The figure shows the interlock and push-button circuits only.

Closing any one of the three start buttons of push buttons *A* will start the 5- and 10-hp. motors and close the interlock on the 10-hp. starter so that the 25-hp. motor may be started when the start button *B* is closed. Stop buttons on stations *A* or *C* will stop all three motors, as will the overload relays. Stop button *B* will stop the 25-hp. motor only, but this motor cannot be started unless the 5- and 10-hp. motors are running.

Assume that start button *A* on the left is closed. This will provide a circuit from the *A* line through the coils of M_2 and M_3 contactors, the overload-relay contacts, the *A* and *C* stop buttons and to the *C* line. Energizing coils M_2 and M_3 causes these contactors to close, and they provide holding circuits from the *A* line through the contacts, the coils and the overload relays to the *C* line, without going through the start button. The start button can now be released and contactors M_2 and M_3 will remain closed. Only the auxiliary contacts are shown, but on the actual control, when auxiliary contacts M_2 and M_3 close, the contacts for the motor circuits also close and the ten- and the five-horsepower motors start.

When M_2 contactor closes, it also closes interlocking contact *L*. Now, when start button *B* is closed, a circuit for M_1 contactor coil is made from line *A* through button *B*, contact *L*, coil M_1 and to the *C* line as for the other circuits. Making this circuit alive closes contacts M_1 and starts the 25-hp. motor. When contacts M_1 close, a holding circuit for the coil is made from the *A* line through contacts M_1, stop button *B*, auxiliary contact *L*, coil M_1, and to line *C*. Since stop button *B* is in the holding circuit for coil M_1, the 25-hp. motor can be stopped by pressing this button.

This arrangement allows the 25-hp. motor to be started and stopped independently of the other two motors as



Control circuits for three conveyor motors

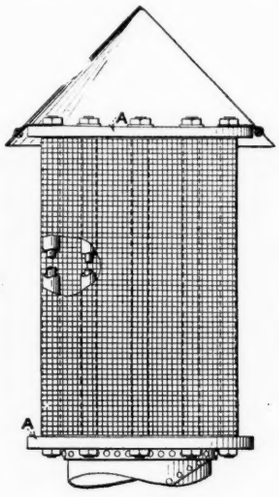
long as these motors are running. As auxiliary contact *L* is closed only when contactor M_2 is closed, the 5- and 10-hp. motors must be running before the 25-hp. machine can be started. If all three motors are running, opening any one of the *A* or *C* stop buttons will stop the 5- and 10-hp. motors. When contactor M_2 opens, auxiliary contact *L* also opens and shuts down the 25-hp. motor. An overload on any one of the motors will open the overload-relay contact on its control and shut down the three motors.

H. W. WIKLE,

Atlanta, Ga. General Electric Company.

Intake Screen for Air Compressors

VARIOUS methods, such as spray washing, wet and dry filtering, etc., are used for cleaning the air before it enters the air compressor. Each has certain advantages, but they all require attention. We believe the high intake is better, and the higher it is above the ground the less dirt will be entrained with the air. We have tried out air intakes at five different heights in different locations. The present is about 65 ft. above the compressor floor and several feet above the power-house roof. We have had no trouble with foreign matter in the air, a little soot being the only thing we have found so far.



Type of screen used on spiral-riveted air intake pipe

We believe that the long, and especially the high, intake pipe when properly sized, has advantages other than giving comparatively clean air. The air at that level is cooler, and this adds to the capacity of the compressor. Again, the pressure, owing to the motion of the air in the long pipe, causes the intake valves on the compressors to open a little earlier and the cylinder to fill a little fuller than with a short pipe. That is, there will be a little greater air head on the intake side of the compressor. Hence, the capacity and efficiency will both be increased.

The illustration shows the head on our intake air pipe with half of the cone-shaped cover removed. The two flanges *A A* are separated by one-inch pipe spreaders and around these spreaders there is wired a sheet of brass wire cloth. The wire of the cloth is No. 12 and the mesh one-half inch. Under the nuts on the upper flange there are placed short bent pieces of $1\frac{1}{2}$ x $\frac{1}{8}$-in. iron, and to these the top is bolted as shown.

Elgin, Ill. L. P. WILBUR.

What Happens to the Pressure, When the Damper Is Moved?

NATURALLY, we expect the steam pressure to rise with an increase of air supplied to the fuel bed, and drop with a decrease. Boiler operation follows these lines, but is it always true? Investigation with a small heating boiler revealed that the pressure usually starts to move "wrong."

This boiler, burning anthracite under natural draft, usually works at 1-lb. gage, sometimes down to $\frac{1}{4}$-lb., or up to $1\frac{1}{4}$-lb. Steam-operated bellows control air supply, holding pressure within one ounce plus or minus whatever pressure suits weather conditions.

It was desired to know how quickly the pressure moved when the regulator was changed for a new pressure. The standard type of gage was too slow. A water manometer was made by connecting the gage-glass drain to a few feet of glass tube so that this formed the outside leg and the water gage the inside leg of the manometer.

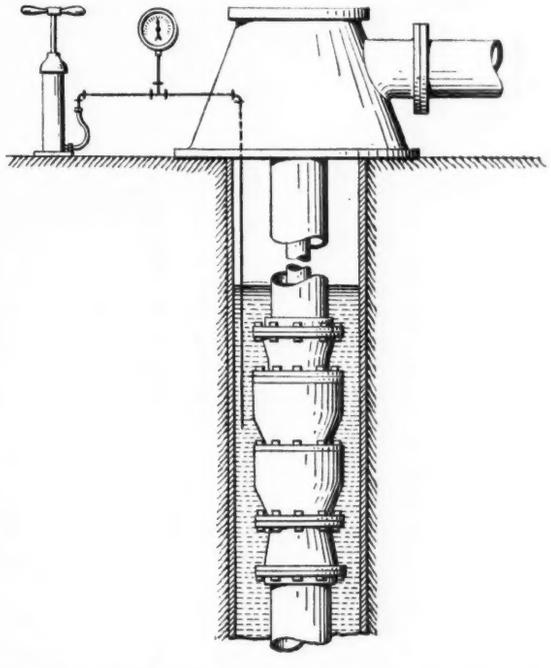
It proved very sensitive and showed the pressure dropping a few seconds after opening the damper. After about one-half minute, during which the pressure dropped about $\frac{1}{4}$ in., it started rising, and came up to the new pressure in the usual manner, in about ten minutes. Other trials were made, closing the damper, and by similar changes of the air admitted under the grate, showing the same phenomenon in each case; that is, the pressure first moved in the wrong direction $\frac{1}{8}$ to $\frac{3}{4}$ in. of water, in $\frac{1}{2}$ to $1\frac{1}{4}$ min. These trials were each made with the fire in a balanced condition, with steady pressure up to the time of air change.

What is the cause of this "backing up" before the start, and is it worth more than a curious glance? I should like to know what others think. It is my opinion that with hard coal the first rush of suddenly increased supply of air passes the fuel bed before there is a definite increase in combustion, therefore the larger volume per minute receives no more total B.t.u. than the former small volume received, and is thus heated less. This larger volume passes the boiler at lower temperature than did the small volume, causing decreased evaporation followed by a pressure drop until the coal starts burning faster and raises the gas temperature. The same reasoning works in reverse direction for decreased air supply.

Lenover, Pa. G. BOYD.

Simple Device for Finding the Submergence of a Deep-Well Pump

THE efficiency of most deep-well turbine pumps is reduced if they are not operated submerged. Many devices have been used to check the amount of submersion, but the best, in my opinion, is the one shown in the accompanying sketch. Passing through the discharge head, in the same manner as the oil lines used on some pumps of this type, is a $\frac{1}{8}$-in. pipe extending to the top of the last stage. The upper end has an ordinary pressure gage and the valve stem of an old automobile tire connected to it.



Pressure required to expel the air through the water above the pump indicates the amount of submersion

Then, by attaching a tire pump, air is forced into the

line, the gage registering the pressure created. As the air pressure is increased, the water will be forced out of the lower end of the pipe. The highest pressure obtainable will be that which is just sufficient to expel all the water, as thereafter the air will vent itself in the well. The maximum reading of the gage is then multiplied by 2.3, and the number of feet of submersion is known.

An altitude gage reading in feet may be used, in which case the submersion in feet will be indicated on the gage. By operating this device before starting a pump and again after starting, the amount of drawdown in the well may be ascertained.

A. C. HcHUGH.

Norwalk, Calif.

Nickel Plating in the Power Plant

IN THE matter of keeping equipment clean and bright nickel plating should not be overlooked. It is not adaptable to all power-plant units, of course, but for smaller units of a troublesome nature it supplies an excellent means of keeping them in shape. For a guide in such procedure the following points are offered.

Nickel plating can be applied to cast iron and steel as well as to brass and copper. For the ferrous metals an undercoat of copper is necessary. This may be a "copper flashing," which is a few minutes' dip in a copper bath, or it may be a heavier coat of longer deposition. It is possible to nickel directly on iron or steel, but a less positive, soft undercoating is best.

Nickel plate is hard and durable. Its luster is brought out by polishing with soft wheels; no one should be afraid to rub nickel that is in use, as long as a harsh agent is not employed with the rubbing cloths. Some polishes are too harsh for nickel and damage it badly. Any polish that would remove rain drops (as on an auto radiator) in one application is likely to be deleterious. If in doubt, the engineer can always fall back on a few ounces of Vienna lime, mixed with common ammonia, which gives him a polish that can be used with safety.

Work that has been carefully plated will not rust. If rust strikes through, it is because the work was not properly cleaned or the plater failed to rinse off the last vestige of acid. Plating cannot be applied over grease, rust or scale. A good plating job will last indefinitely, but a competition coat may begin to peel in a few months.

Nickel plating is much less expensive than generally supposed. The cost increases with the amount of labor spent in preparing the surfaces. Perfection of finish is obtained by perfection of the surface to be plated. Scratches in the original show up in the plate—it is the time spent in buffing out scratches and other imperfections that increases the cost of the several operations.

It is folly to demand as perfect a finish on a power-plant part as on a high-priced car. By definitely stating that scratches and minor imperfections are allowable, the cost of a job is held down considerably; what is wanted is a protective coating and general appearance, practical rather than ornamental. So many of the parts that might be wished plated, in the field we are considering, are already bright through machine-shop finishes or rolling that the long preliminaries toward successful plating do not have to be done.

Variations of plating might be mentioned. A coating of brass or copper, electro-deposited, is often desirable. Zinc is well adapted to plating on iron and steel. As a protective coating, applied by this method of "cold galvanizing," it is one of the most valuable of plates. Black nickeling is an interesting variation of the plating process, one that makes contrasting effects and one obtainable from the larger platers. Although ordinary nickel plate is distinguished by its high polish, it may be had without this. In such cases the work simply does not go through the final buffings. It is known as a "white dip"—a silver-colored finish that does not reflect light and is often most desirable.

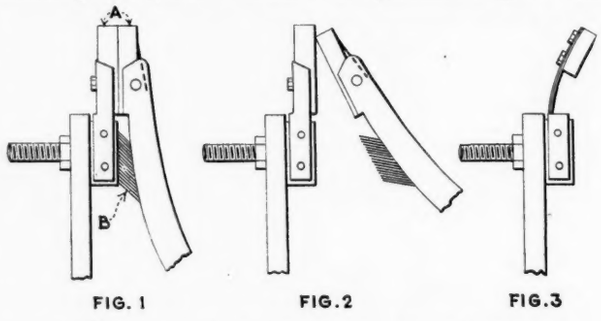
D. A. HAMPSON.

Middletown, N. Y.

Carbon Contacts Break on Circuit Breaker

ON A circuit breaker used on a railroad generator, the contacts were arranged as in Fig. 1, *A* being the carbon-to-carbon blocks and *B* a copper-to-copper contact. When closing, the carbon contacts come together first, as in Fig. 2. If care was not used when closing the breaker, the stationary carbon would sometimes be broken, owing to the way it was attached to its support. The tip of the movable carbon striking the stationary one, as in the figure, had a tendency to bend it backward before the former came into the closed position.

The breaker also developed a tendency to fail to latch closed properly and to stick in the position, Fig. 2. This



Figs. 1 to 3—Contacts on circuit breaker

Fig. 1—Original contacts. Fig. 2—Position of breaker that caused the carbon contacts to be burned off. Fig. 3—Improved carbon contact.

allowed all the current to flow continuously through the carbon contacts. One day the operator attempted to close the breaker, but left it in the position shown in Fig. 2. Shortly after this a heavy overload came on the line and the arc on the carbon contacts burned them off, which made necessary a repair job with what could be picked up around the plant.

A new support to hold the stationary carbon block was made from a piece of heavy spring taken out of an old clock. Before assembly, the spring was bent to the shape in Fig. 3. Bending the spring this way caused the breaker to open more quickly. A new spring made from the clock spring was also put behind the movable carbon contact. To increase the conductivity of the connection between the stationary carbon and copper contacts, the spring on the carbon was shunted by a flexible copper strip.

When the springs were cut to the desired length, they were found to be too hard to drill. To make the holes, the springs were placed on a piece of iron, a prick punch held on the center of the intended holes and hit a sharp blow with a hammer. This operation caused bulges on the spring where the holes were to be made. The bulges were then ground off on an emery wheel. If the hole was not large enough, the spring was again given the prick-punch treatment on the opposite side from the first and the bulge produced ground off.

Brunswick, Me.

LEON L. POLLARD.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Reflex Water Gage with Flat Glass for High Pressure

THE illustration shows the improved "Klinger" reflex water gage (type BK) for working pressures up to 250 pounds.

The important improvement made in the design of this gage is the use of a single row of back screws in place of the double row (one on each side) formerly used. The employment of a single row of screws precludes the possibility of straining the gage body or breaking the glass through uneven adjustment of the screws.

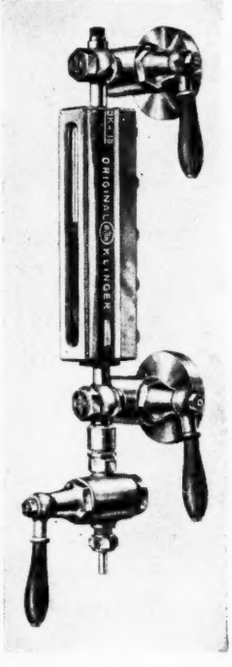


Fig. 1 — Assembly of gage and cocks

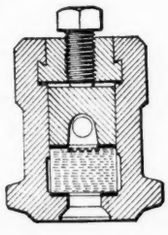


Fig. 2—Glass is tightened in body with single row of screws

Another important feature of the gage is the use of gage cocks fitted with interchangeable elastic packing sleeves and on which no stuffing boxes are used. The sleeves of special packing completely inclose the plug in the body, thus protecting the plug as well as the body of the cock against the action of corrosion or wear. It is pointed out by the manufacturer that no regrinding of the plug or body is ever necessary, for in case of leakage the packing sleeve is replaced with a new one.

The main body of the gage illustrated is also made in the type BK, in which the body is fitted with straight ends for fitting into ordinary gage cocks in place of glass tubes. The gage cocks, as well as the body, are made of gun metal. In operation the water in the gage appears black, the steam silver, the contrast making the water level easily readable from a considerable distance. Gages of this type are also obtainable for pressures up to 1,500 lb. The gage is distributed by Klingerit, Inc., 16-22 Hudson St., New York City.

A New Indicator for Combustible Gases

A PORTABLE instrument that detects the presence of a wide range of combustible gases or vapors and indicates whether the atmosphere containing these gases is safe to breathe and safe for flames of fire, is announced by the Union Carbide Company, 30 East 42nd St., New York City. This device is a modification of the methane indicating detector made by this company. It utilizes the effect of combustion of flammable gas and air mixtures on the surface of a heated filament. This combustion increases the temperature and, consequently, the electrical resistance of the filament. This change in resistance causes the needle of a meter to move over a scale, from which the desired information relative to gas conditions is obtained. The indicator comprises the following parts: Detector head or combustion chamber; meter case; portable storage battery.

The detector head consists of a cylindrical metal case or bonnet which screws to a metal base equipped with a short carrying handle. The bonnet is provided with louvers, or small openings, which permit the atmosphere being tested to circulate about the heated filament. Within the bonnet are three concentric gauze screens of a type similar to those used in flame safety lamps, which prevent the ignition of an external gas and air mixture. In the center of the chamber formed by these screens is the filament cartridge. The detector head is so constructed that accidental incorrect assembly of safety screens and filament cartridge renders the circuit inoperative.

A flexible twin conductor cable about fifty feet long connects the detector head with the meter case, in which are inclosed the various resistances in the detector circuit, the indicating meter, the control switch and a rheostat. A short flexible cable connects the meter case to the portable storage battery which supplies the power to operate the indicator. The storage battery is carried on a leather belt worn around the waist. The indicator is made ready for operation by throwing the control switch first to the "Filament" position, then a few seconds later to the "Meter" position. Zero adjustment in fresh air is next made by turning the rheostat knob. The operator then places the detector head in the atmosphere to be tested and reads the meter. The detector head may be held in the hand, raised vertically or extended horizontally on a pole, or lowered by the cable into a manhole, tank or elsewhere.

Operator with combustible gas indicator

For the operator who desires to know the percentage of a known combustible gas present in a mixture of that gas and air, the meter scale reading is taken and then referred to the particular curve or chart prepared for that gas. From the curve chart the operator reads directly the per-

centage of gas present corresponding to the scale reading of the meter. The gas charts are plotted with meter scale reading as the horizontal axis and the percentage of gas as the vertical axis.

If an unknown mixture of flammable gases exists and the operator desires to know whether or not the mixture is explosive, the meter scale reading is taken and referred to a "Per Cent of Explosibility" curve.

Some of the important features of the combustible gas indicator pointed out by the manufacturer are as follows: Sampling and laboratory analyses are eliminated; indications are immediate; explosive mixtures of gas and air are indicated by continual oscillation of the meter needle; continuous observations may be made while men are working in gaseous atmospheres; all accessible parts of tanks or compartments can be thoroughly tested for gas pockets; the detector head may be lowered into a tank while the operator remains outside; the entire outfit is safe to operate in all gas-air mixtures except those containing acetylene or hydrogen.

The indicator will be distributed by the safety appliance department of the Union Carbide Sales Company, New York City, and by Bullard-Davis, Inc., 67 Wall St., New York, and 275 Eighth St., San Francisco, Calif.

Fig. 1—Style C, suitable for use with light-weight welding and lead-burning torches

"Gasavers" for Use with Welding Torches

NOT only is it possible to conserve welding gas, but with the styles C and G "Gasavers" illustrated, a saving may be effected in the time that is usually required to adjust the torch flame, when the work is temporarily held up. When the torch is hung on the arm projecting from the "Gasaver," the flame is extinguished and the gas flow stopped. By lifting the torch from the arm and passing it over the handy pilot light at the top of the "Gasaver," it is lighted, the same flame as originally adjusted being secured. In addition, these accessories act to prevent accidents.

The unit is placed between the regulators and feed lines of the cutting and welding torch. Both gases are

Fig. 2—Style G, provided with extra-large opening valves

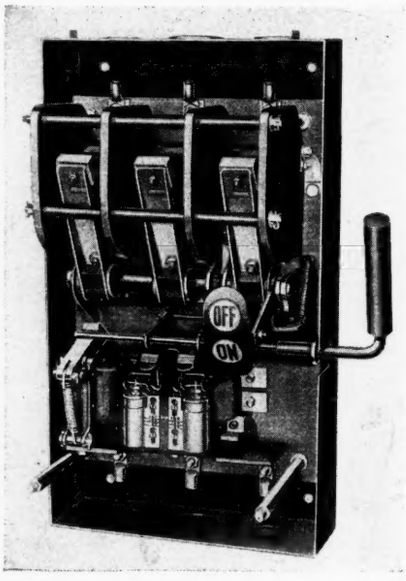
passed through the device, control of which is governed by its projecting arm acting on two positive-seating spring valves. The adjustment of these valves can be made readily by two small setscrews directly over each plunger. When the torch is held on the arm, the weight closes both valves. The style C unit was designed especially for light welding and lead-burning torches, using illuminating gas and oxygen or compressed air. Style G, for use with acetylene and hydrogen, or illuminating gas and oxygen, is provided with extra-large openings in the valves for heavy-duty work. The "Gasavers" are put out by the Weldit Acetylene Company, Detroit, Mich.

Fully Inclosed Circuit Breaker

THE type EAF breaker illustrated is essentially a non-closable on overload type of breaker designed primarily for industrial work. It is inclosed in a two-piece steel case so designed that the cover may be completely removed from the bottom by simply taking off two wing nuts. The breaker proper is mounted on a slate panel, and this panel may be removed from the case by taking out four corner screws.

The breaker is closed by pressing down an insulated handle which projects from the right-hand side of the case. Knocking the handle upward opens the breaker. A moving target indicates the "open" or closed" position.

All breakers of this type are equipped with a barrier unit separating the arcing members from each other. This unit may be readily removed without tools, making it possible to inspect instantly the contact members and carbons. The breaker is built in either two- or three-pole combinations, the overload coils being standard equipment in either case. The two- and three-pole breakers are exactly the same size, the only difference being that the center pole is omitted in the case of the two-pole combination. The overload trip consists of electromagnets whose armatures may be set at different points of calibration by means of two setscrews. Breakers are calibrated from the normal rating point to a point 100 per cent in excess of normal. The overload coil units are such that they may be replaced in the field, either with



Breaker with cover removed

others of the same size, or ones of a different capacity.

Time limit protection is afforded by means of simple dashpots which give quick resetting and are free from oil overflow.

Either one or two under-voltage attachments can be placed on any type EAF breaker without modifying the original structure. The under-voltage attachments are held in place by means of two screws accessible from the front. On standard three-pole breakers one under-voltage unit is supplied as standard. If it is desired to open the breaker from a distance by means of a shunt coil, a shunt trip device can be added. The breaker, which is put out by the Roller-Smith Company, 233 Broadway, New York City, is available in capacities from $\frac{1}{2}$ to 80 amperes 250 volts direct current and 550 volts alternating current.

New Electric Strip Heater

A NEW electric strip heater, suitable for use either as an air heater or as a "clamp-on" device, is illustrated. It is 24 in. long, 1½ in. wide, ⅜ in. thick and is rated 500 watts at 110 or 220 volts. Slots are provided in each end, allowing the heater to be supported in the air or clamped to a metal surface.

Strip heater

Both terminals are at one end of the unit and project from the same side. They are nickel-plated brass studs insulated from the sheath by mica washers and provided with screws and fittings for binding the connecting lead wires. The current-carrying resistance wire inside the sheath is the usual nickel-chromium resistor wound in a helix. The coil is supported at each end by a porcelain insulator and is stretched down the length of the unit four times, providing even distribution of heat over the entire surface of the unit.

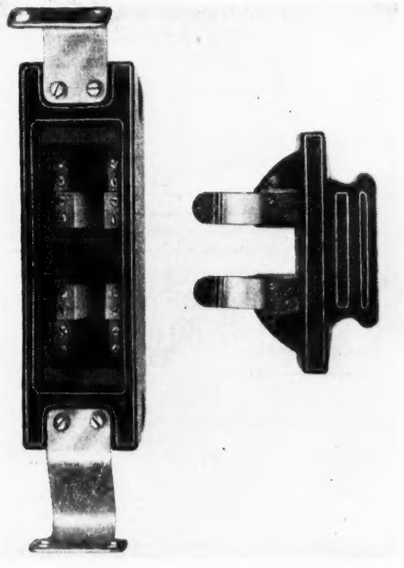
The resistor is insulated from the sheath by magnesium oxide powder. After the heater is assembled and filled with magnesium oxide, the powder is compressed into a compact mass. At the same time four ridges are produced in the top side of the unit and these, together with depressions between, place each of the four heater windings in what are essentially individual half-tubes, adding strength and rigidity to the unit. The heater is put out by the General Electric Company, Schenectady, N. Y.

Cutout for Series Lighting Circuits

THE Peerless cutout, illustrated, is designed to afford an easy and safe means of totally disconnecting the lamp circuit and the high-tension underground system. It consists fundamentally of two parts—a plug assembly with film, and a receptacle assembly. When the plug is removed from the receptacle, both the line and lamp circuit are independently short-circuited and are insulated from each other. When the plug is inserted in the receptacle, the two line contacts are connected with the two lamp contacts and the circuit is completed.

Both the plug and receptacle are made of wet-process porcelain with a barrier between the lamp and line circuit providing a long leakage path. The unit is designed to withstand a dry flashover test of 40,000 volts. The conductor and contact surfaces are nickel plated, affording good contacts and preventing corrosion.

Failure of the lamp will cause only momentary open circuit, as the film provided with the cutout is connected in multiple with the lamp, so that if the lamp fails, the voltage across the film rises above normal, causing the film to puncture, short-circuiting the lamp circuit and maintaining the series circuit. The cutout is manufactured by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.



Cutout with plug

Light-Weight Water-Cooled Carbon Electrode Holder

A NEW type water-cooled carbon electrode holder for heavy-duty manual welding by the carbon-arc process is announced by the Lincoln Electric Company, Cleveland, Ohio. Although designed primarily to insure greater comfort and less fatigue for the welder operator, the new holder also effects a considerable economy in the use of carbon electrodes.

It is pointed out by the manufacturer that it is possible to weld with the arc tip of the carbon electrode projecting less than three inches from the holder. Consequently, there is less carbon area heated, and the vaporization of the carbon is reduced. Thus it is possible to use smaller carbons with higher current density, which effects a decided saving in electrode costs. Furthermore, several innovations in design have made it possible to produce the new-type holder at a weight of only 3¼ lb. in the operator's hand.

An important feature, which contributes to the light weight of the holder, is the use of the hose that carries the water to carry the cable to the holder. Each of the water tubes contains a small light cable from the connector to the holder. The water flowing through the holder acts as a cooling agent for the cables. By the use of this cooling agent the size of the cable to the holder is reduced to a fraction of what would otherwise be necessary.

The holder consists of coiled copper tubing through which water constantly circulates, the carbon electrode being inserted through the coil. The holders are manufactured in sizes for use with ¼-, 5/16-, ⅜- and ½-in. carbons. A hand shield of compressed magnesium protects the operator's hand from the arc rays. The water-cooling system is incorporated in the hand grip of the holder to keep it cool.

Water-cooled carbon electrode holder, type W

FROM AMONG THE READERS

Conducted
By
L. H. Morrison

First American Installation of a Steam Accumulator.—*When was the first accumulator installed in America?* J.C.W.

The International Harvester Company installed an accumulator, designed by Professor Rateau, in 1907. This accumulator carried a pressure of 0.2 lb. gage, and received about 50,000 lb. of steam per hour.

Object of Double-Ported Engine Valves.—*What is the object of providing an engine with double-ported valves?* A.H.C.

The purpose of using a double-ported valve is to obtain the desired area of opening with half as much movement of the valve, thereby reducing the loss from friction and wear of the rubbing surfaces and securing the advantages of a single-ported valve with twice the length of port opening.

Condenser Pressure Not Ascertainable from Temperature.—*Why cannot condenser pressure be known by simply observing the temperature and ascertaining the corresponding pressure from a table of the properties of steam?* W.A.G.

The absolute pressure within a condenser is made up of the pressure due to the steam or water vapor present and the pressure due to the gases present, generally called air, as the greater part of such gases consists of air. The total condenser pressure cannot be obtained from steam tables because the temperature is that corresponding to the pressure of only the saturated steam that is present, which would be something less than the total pressure.

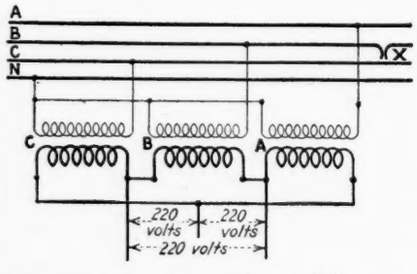
Use of Air Chambers with Pumps.—*Why are some pumps made with air chambers, while others are not?* K.R.C.

The purpose of an air chamber is to provide an elastic element for taking up the shocks and irregularities and for inducing a uniformity of flow in the pipe line. In single and in duplex single-acting pumps, although the reversal of stroke may be thought instantaneous, there is of necessity a momentary stoppage that is attended by an interruption of the flow, and for smooth running an air chamber is necessary to take up some of the water during the stroke and replenish it during the pause.

An air chamber should be used with crank and flywheel pumps of any type, on account of the rapid fluctuations of piston speed, but it may be dispensed with in duplex double-acting low service pumps, in small duplex pumps for general service and in small slow-running pumps such as deep-well bucket pumps, and for use with centrifugal and ordinary types of rotary pumps where the flow is nearly continuous.

Operating Transformers Open-Delta.—*On our power system is a bank of transformers connected star on the primary and delta on the secondary, as in the illustration. If one of the lines was broken, for example, as at X in line B, could the transformers be kept in operation to supply the load, while the line is being repaired?* M.G.

The transformers may be operated in this way, but their capacity will be reduced to 57 per cent of the rating of the



Transformers connected star-delta on a four-wire three phase circuit

three. It is advisable to cut transformer *B* off the circuit, since closing the line at *X* will cause this transformer to pick up load. This might cause a bad arc when the two ends of the wire are brought together. Furthermore, the potential on the transformer side of the break will be lower than on the line side. How much the difference of potential will be depends on the load on the transformers.

Averaging Pressure Charts.—*Is it possible to find the average pressure of a circular chart by finding the area inclosed by the pressure curve and calculating the average radius by comparing the area with a circle of the same area?* G.S.K.

This method will not give accurate results when the variations in pressure are large. Averaging instruments are built by which the mean steam pressure can be obtained from circular charts, and you should write the maker of your pressure recorder to supply you with one if the variations in pressure are considerable.

The World's Largest Stack.—*An argument arose at our local engineering association as to the location of the largest stack. We decided to put this question up to the editor of Power's "Question and Answer" page.* M. C.

There has been much confusion with regard to which is the record stack. In some cases the stack height has been given from the top of the base and in others the height of the concrete block making up the base has been included.

By far the largest, but not the tallest stack in the world, is that at Anaconda, Mont., which is 555 ft. above the base and has a diameter of 75 ft. at the bottom and 60 ft. at the top. A Tacoma, Wash., stack holds the record as being the tallest. It extends 572 ft. 10 in. above the foundation block and has an inside diameter at the bottom of 40 ft. and at the top, 24 ft.

From this you will see that although the Tacoma stack is the tallest, it has much less gas capacity than the Anaconda. Both of these stacks are brick. The tallest reinforced concrete stack of which we have record, is that of the Kuhara Mining Company, Saganoseki, Japan. It is 550 ft. above the base.

Of course the elevation of the base of these stacks will vary, but the datum line by which comparisons can be made is the base or foundation block.

Causes of Failure of Injector.—*What may be the cause of failure in operation of an injector? The tubes and parts are clean and show very little wear.* C.J.S.

The trouble may be due to a leaky suction pipe. Plug the ends of the suction and overflow pipes; then turn on the steam and the location of any leaks will be indicated by an escape of steam.

The injector may be too hot to start, owing to a leaking steam valve, or the feed water may be too hot. The suction pipe or strainer may be obstructed. Such obstructions usually can be removed by turning on steam after blocking the overflow and closing the delivery to the boiler. The delivery pipe may be choked or the check valve may be faulty, either of which would be indicated by discharge at the overflow or inability to maintain the usual water level in the boiler.

To test for these defects, place a pressure gage on the delivery side of the injector and note whether it indicates a pressure in excess of the boiler pressure. It may be that the steam supply pipe is choked or that the injector is supplied by wet steam caused by foaming or priming of the boiler. The steam supplied should be taken from an independent connection out of the highest part of the boiler to insure dryness. On the other hand, superheated steam will not usually give results as satisfactory as dry saturated.

PROBLEMS

ANSWERS

from Our Readers

THE QUESTION

WHEN a safety valve opens, the water immediately below it lifts up with a geyser effect. What causes this? P. S. B.

WHEN a safety valve opens, the pressure in the part of the drum immediately under the valve will be momentarily lessened in comparison with that in other parts of the drum.

Localized violent boiling will set in, and water will be carried up with the steam, producing a geyser-like action, continuing until the flow through the valve has attained its maximum value.

This action will depend a great deal on the height and condition of the water and the rate of steaming.

Duluth, Minn. L. M. LARSON.

WHEN the safety valve opens the pressure drops and steam from the water and from the steam space rushes toward the opening. The water level in a boiler rises when steam is drawn from it, owing to the bubbles of steam within it that are rising to the surface. How much the water will lift depends upon the pressure drop, the proximity of the water to the opening or whether the water is ready to foam. The water will lift highest where the pressure drop is greatest; that is, under the valve. W. L. PARKER.

Elgin, Ill.

WITH the safety valve closed, the temperature of the water corresponds to the steam pressure; that is, the temperature necessary to boil or give off steam at the pressure carried on the boiler. The safety valve suddenly opens, relieving some pressure on the water directly under the valve; the water now has an excess temperature and gives off steam faster, the action extending a few inches below the surface. The water below the surface tries to turn into steam so quickly that a small eruption occurs, the steam bubbles throwing the water upward into the stream of steam leaving the safety valve. This continues as long as the safety valve is open because the pressure is going down all the time. I. F. RICHMOND.

Claremont, N. H.

REGARDING the question of P. S. B. in *Power* of Feb. 5, relative to the geyser action of the water in a boiler when the safety valves lift, my theory is as follows:

The water in the boiler is all at the temperature due to the pressure, which is equal over all the liberating surface when the safety valve is closed. When the safety valve lifts, it lowers the pressure slightly in the immediate vicinity adjacent to the valve, and on the surface of the water near the same. This action causes the water in this area to give off more steam instantly, causing a violent boiling up of the water in the area affected, thereby causing the geyser action.

If the safety valve has a baffle plate suspended a few inches below its opening, the discharging steam will be drawn from over a larger surface, thereby minimizing the disturbance over any part of the liberating surface. A dry pipe in the form of a tee with nipples the full size of the safety valve inlet, extending about four times the pipe diameter on either side of the tee will distribute the steam pull over sufficient area to stop the geyser action under ordinary conditions.

Cleveland, Ohio. C. A. GREEN.

THE rapidly rising steam bubbles near the safety-valve outlet do not have time to separate entirely from the water before flowing into the safety-valve outlet. Owing to the steam flow through the valve the pressure on the surface of the water below the valve is reduced slightly below that existing in other parts of the boiler, consequently, the water will rise higher near the outlet.

This phenomenon is no doubt prevalent in all boilers, but it is somewhat more pronounced in some types of water-tube boilers, where the water level will rise a noticeable amount when the safety valve opens, and it will fall when the valve closes.

Leavenworth, Kan. HARRY COUTRELL.

THIS geyser effect is due to an unusual quantity of steam being formed instantly in that portion of the water directly below the safety valve. This steam is in the form of numerous small bubbles which rise rapidly to the surface. As this column of mixed water and steam bubbles is lighter than a column of the surrounding water alone, there will be an action similar to that of an air lift, causing a rapid upward current in the water at this point. A hump will therefore form on the surface of the water of sufficient height to drain away the water brought up by the steam lift.

Lake Charles, La. M. F. KNOY.

ASSUME that in a certain boiler steam is carried at a pressure of 250 lb., therefore the water in the boiler is at a temperature of 406 deg. F. When the safety valve opens, the pressure in that immediate vicinity is suddenly lessened to, let us say, 246 lb. Consequently, this pressure on the surface of a small area of water directly under the valve is slightly less than that on the surrounding water. The water thus affected is at the same temperature as in the rest of the boiler, although the boiling temperature at 246 lb. gage is 404 deg. F. But as the pressure on it has been suddenly reduced, this small area of water will change to steam immediately, causing an upheaval, or a geyser effect.

Austin, Tex. T. A. HINTON.

WHEN the safety valve opens, the sudden demand for steam causes a slight reduction in pressure and results in the rise of jets of water all over the surface. These jets are caused by the sudden generation of steam in the entire body of water.

In many boilers of limited steam space the water will actually be discharged in the form of spray from the safety valve opening. This is the result of there being a greater pressure difference in the space immediately under the valve on account of the current of steam that is flowing out and the action on the water is similar to that of a water spout on the ocean. G. H. KIMBALL.

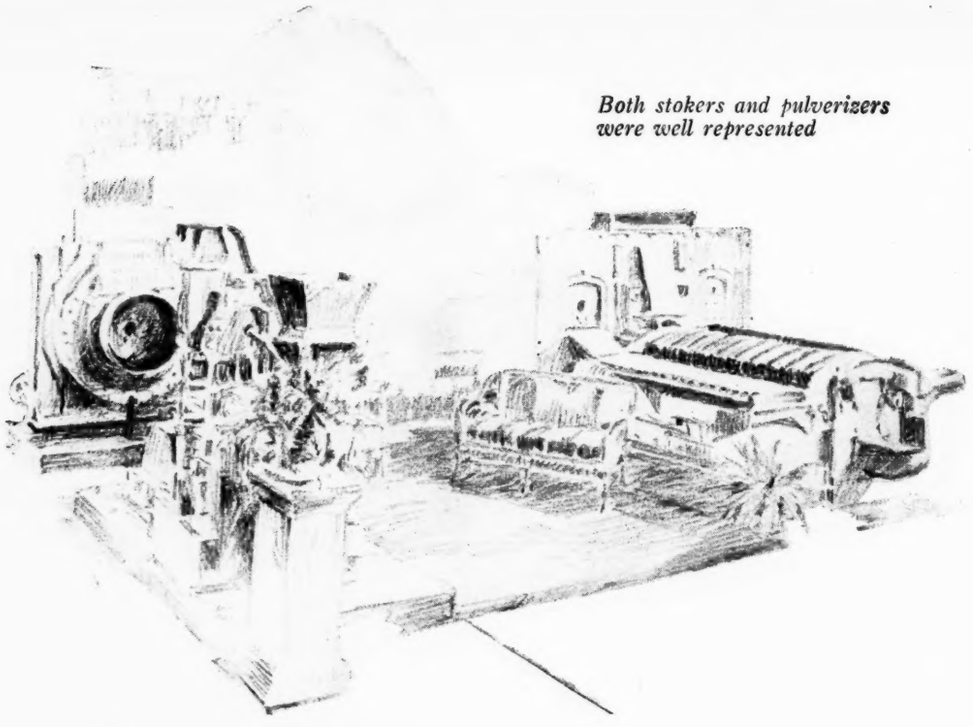
Cambridge, Mass.

A Question For Our Readers

IN A plant containing an alternating-current engine-generator set having a shaft governor which operates in parallel with a transmission line, how can I substantially alter the load the engine carries?

G. R. P.

Suitable answers from readers will be paid for and published in the March 26 issue



Both stokers and pulverizers were well represented

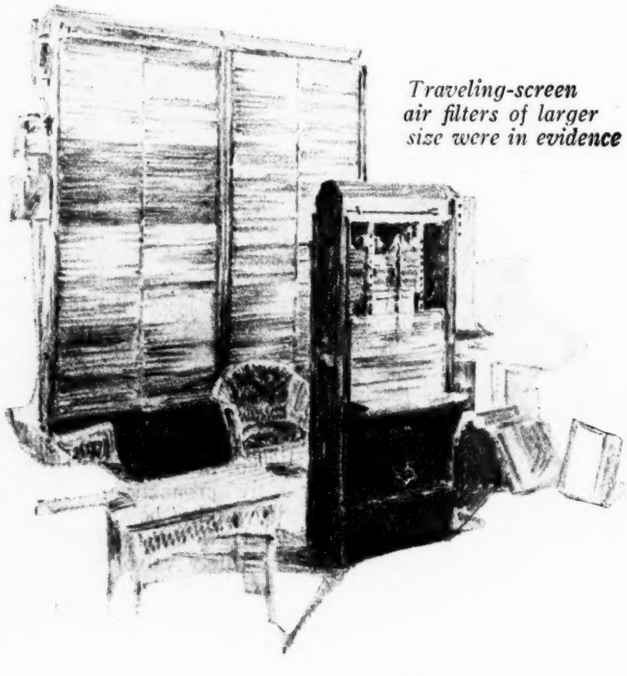
Many Helpful Exhibits Seen At Chicago Power Show

CHICAGO held its fourth Power Show at the Coliseum from Feb. 12 to 16, with the products of over two hundred and fifty manufacturers on view. To say that it was bigger and better than the previous shows would not present an accurate picture. In many respects it measured up well to its predecessors, although the character of some of the equipment shown was somewhat different, and its interest to the visitor must be judged by his responsibilities. For instance, some of the larger equipment shown in former years was missing—there was a noticeable lack of prime movers. On the other hand, there was considerable equipment falling within the sphere of the power engineer's duties but not directly concerned with power generation.

From this it should not be inferred that power generating equipment was lacking, for there was much of this that was of an interesting character. On the whole, the exhibits probably held more for the industrial or building power engineer than for the central station man. All in all, however, it was essentially a "power show."

No descriptions will be given here of the new apparatus or improved designs that were shown. These, with few exceptions, were described in *Power* for Jan. 29, 1929. The following general impressions are indicated for the benefit of those who were not privileged to attend.

Boiler exhibits were few, but worthwhile. Refractories and water-walls were well represented, with interest centering on several full-sized sections of water-walls of both the bare and re-



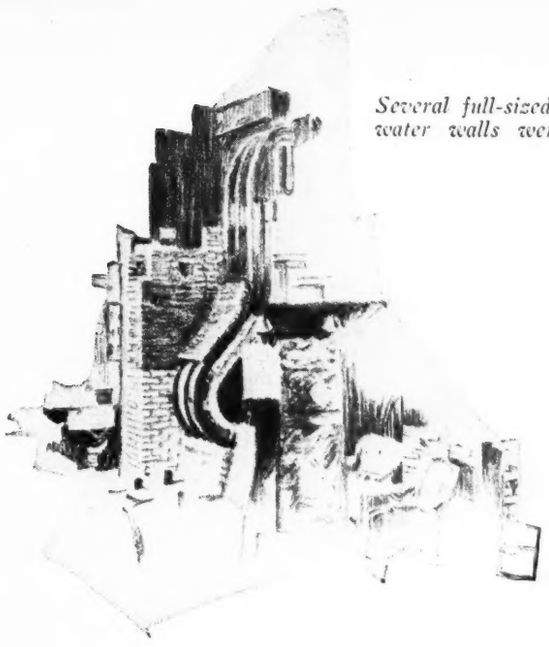
Traveling-screen air filters of larger size were in evidence

fractory protected types, which served to demonstrate the methods of construction that have proved successful in operation.

Many stokers were on view. Some of these were designed for use with large boilers, although the greater number were for smaller installations, particularly for replacing hand firing in industrial and heating plants. Improvements among the former type covered driving mechanisms, air control and, in one case, an over-feed agitating section fitted to the rear end of a large underfeed stoker. The smaller stokers were of the over-feed, pusher and screw types. Most of them were adapted to relatively low settings and were self-contained as to coal feed and forced-draft fan drive. One design included furnace doors hung on roller bearings, giving ease of opening and closing. Hydraulic pusher mechanisms of the geared-oil-pump type were in evidence. An inclined chain grate of improved design was also shown.

Pulverized-coal exhibits emphasized the trend toward adopting this method of firing in the smaller plants. Half a dozen unit mills were shown, some of which incorporated improved designs such as modifications in the pulverizing elements, underfeed and control. A feature of this equipment was a portable type of unit mill for use in plants equipped with one spare boiler, in which it reduces by one the number of mills needed.

Fine ash and cinders are still a problem in pulverized-coal installations, as was apparent from the several new types of collecting equipment shown. These embodied special fan designs, water-spray washers and various types of baffled catchers. One of the latter had an ingenious rapping device which serves to clean the baffles at regular intervals by moving them upward and allowing them to fall back against a projection of the frame.



Several full-sized sections of water walls were on view

Air preheaters were much in evidence and distinct advances were shown. A plate design was of all-welded construction, built in units and arranged for quick and easy replacements of small sections, making for low maintenance. Another type embodied a new heating element, said to permit of much greater capacity for a given amount of space.

Pumps were well represented but little of note was shown except in vacuum pumps. One of these was of the rotary type, provided with synchronous motor drive, while another was so designed as to avoid the possibility of becoming airbound. Most of the pumps exhibited had improved bearings, with a much freer use of anti-friction designs than in former years.

Feed-water conditioning occupies a much more important place since the advent of higher temperatures and pressures, as was evidenced by the equipment shown. One display combined a system of deconcentration and separation with zeolite softening, for which much advantage was claimed.

Safety in the boiler room received its meed of attention, evidenced by the large number of exhibits of metal flooring and stair treads. Some of these have been greatly improved as to strength, appearance and ease of erection.

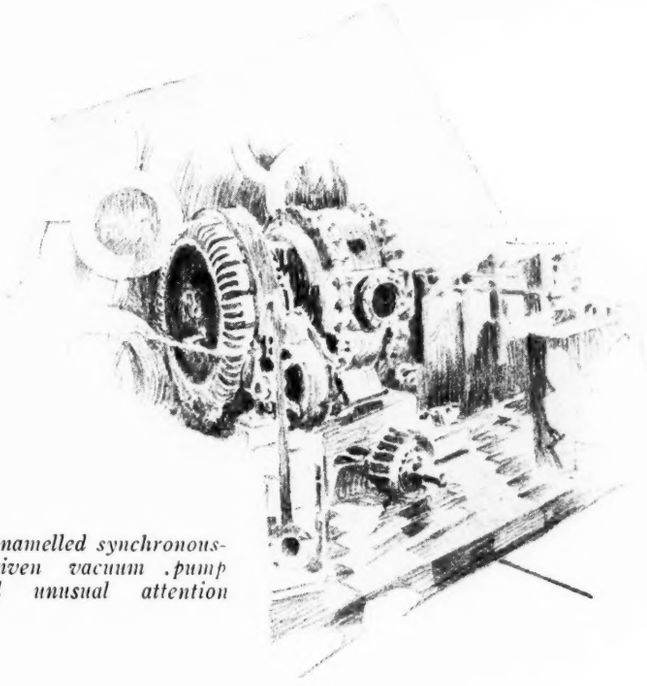
Evidence of the fact that many power engineers are concerned with heating was to be found in the large variety of heating equipment shown. Unit heaters led the list, reflecting the large increase in popularity of this type. Many improved designs of this equipment were shown. The appearance of the heaters, in particular, has been greatly bettered, chiefly by the application of lacquers and other finishes.

Heating control systems and other heating accessories were also in evidence. The trend in control is toward suiting the amount of heat supplied to the weather conditions.

Air filters were on display by several manufacturers with types ranging from the water-screen filter through the traveling screen to the viscous liquid design. In this latter style, some new designs showed a trend toward easier handling and renewal, while traveling screens of larger size than formerly were exhibited.

The usual number of traps were to be seen, but these embodied little in the way of radical changes in design. Gaskets and other forms of packing were shown by several manufacturers, with improved metallic packings as a feature.

Coal handling and weighing equipment included one new, improved type



A lilac-enamelled synchronous-motor-driven vacuum pump attracted unusual attention

of belt conveyor, equipped with idlers having anti-friction bearings. The usual interesting working models of drag-scraper coal-handling systems were in evidence, while one maker showed an improved scale for weighing coal in transit on a belt.

One exhibit that aroused much interest was that of a right-angle bend for a duct. This bend was equipped with guide vanes for directing the gases in the correct path and an efficiency much higher than that obtainable from long radius bends was claimed for it.

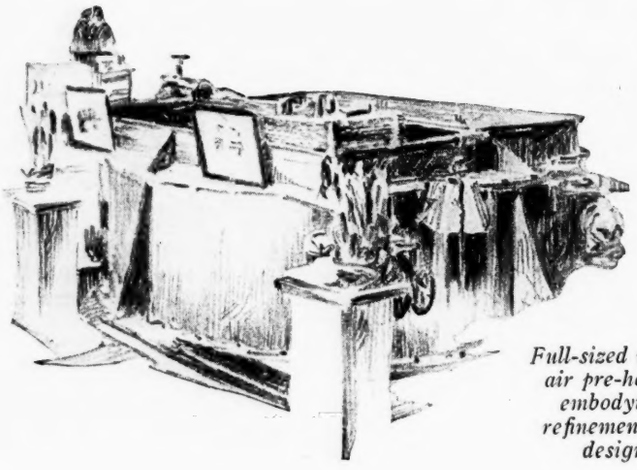
Unlike former years, few of the large valve manufacturers were present. Those that exhibited confined their displays largely to the smaller valves. This does not apply to safety valves or blowoff valves, of which two or three interesting, if not strictly new, designs were shown.

Several instrument companies had booths and their exhibits were excellent, although the new things they had to show were largely minor refinements. New systems of boiler control were shown, but these did not differ greatly from some already in use. The trend to flush-type instruments was evident, though some makers showed new lines of vertical, inclined scale instruments. In water columns the influence of higher pressures was evident in the increased sturdiness of the examples shown.

On the whole, the attendance appeared to be satisfactory as to numbers and quality, considering that power shows are no longer a novelty. Agreement among exhibitors on the point of attendance is difficult, inasmuch as each is prone to view the matter from the standpoint of his own particular line; but all agreed that the attendance from the ranks of industrial power engineers was relatively greater than usual.

The first part of the week was not so good, but this was offset by the attendance later. This fact is probably traceable to the mechanical engineering sessions of the Mid-West Power Engineering Conference having been held on Thursday and Friday, while the earlier meetings of the program were devoted to civil and electrical engineering subjects. It was also unfortunate that the show had to be held at a considerable distance from the meeting-place of the conference.

However, all things considered, the show was a success. It was instructive, it was well attended and managed, and it served its purpose of bringing manufacturer and prospective buyer into more intimate relations, which, after all, is the chief purpose of all shows.



Full-sized rotary air pre-heater embodying refinements in design

Recent Publications

MATERIALS HANDBOOK—An Encyclopedia for Purchasing Agents, Engineers, Executives and Foremen. By George S. Brady, Associate Editor, *American Machinist*. Published by McGraw-Hill Book Company, Inc.; 370 Seventh Ave., New York City, 1929. Artificial leather; 4x7 in.; 428 pages. Price, $4.

TWENTY years ago—when machinery was practically all made of cast iron and mild steel—when a refractory was a fire-clay brick—the power engineer needed to know little about construction materials.

Now—with the advent of alloy steels and many non-ferrous metals and alloys as essential raw materials of power-plant equipment—with a thousand other materials used around the plant for one purpose or another—the power engineer must know something about the materials that make up the apparatus he buys and operates.

This information has always been available in the encyclopedias; but these are seldom at hand when the need arises and are rather too costly to be on the bookshelf of most plants. Besides, the information they give is detailed and lengthy, and what the busy engineer wants is a brief summary of the properties of the materials he looks up.

These needs of the engineer are well met by the "Materials Handbook," which covers, in a brief way, about 2,200 different materials. Headings under which these substances are listed include abrasives, brasses and bronzes, building materials, corrosion-resistant alloys, cupronickel alloys, fabrics, leathers, organic materials, fibers, finishing materials, heat-resistant alloys, industrial chemicals, irons, light alloys, metals, miscellaneous alloys, minerals, military chemicals, commercial explosives, oils and greases, ores, refractories, resins, gums and waxes, steels, white metals, and woods.

The following excerpt is typical of the treatment throughout the book:

"*Valve copper.* A general trade name for copper casting alloys used chiefly for making "copper" valves and pipe fittings. It may vary widely in composition, but should cast readily without cracks, checks or porous spots, and will flow in the mold better than copper. It may contain simply tin, zinc or lead, or all of these. A composition used by the Parker Appliance Company, Cleveland, is Copper, 88 per cent; tin, 4 per cent; zinc, 3 per cent; lead, 3 per cent; and nickel, 2 per cent. It has a tensile strength of 30,000 lb. per sq.in., yield point of 15,000 lb. per sq.in., and elongation of 15 per cent."

It will be readily seen that to have such data available is of great value to anyone who purchases equipment. The book is deserving of space in the desks of power engineers.

MECHANICAL WORLD ELECTRICAL POCKET BOOK. Published by Emmott & Co., Ltd., 65 King St., Manchester, England, 1929. Cloth; 4x6 in.; 326 pages; 125 illustrations; tables. Price, 50 cents.

THIS little book has been issued annually for twenty-two years. It contains practical information on a great many electrical subjects, such as alternating-current and direct-current systems, motors and generators; storage batteries; rotary converters; wire and cables; illumination; locating faults in direct-current and alternating-current motors, etc. There are also many tables that give the sizes of motors required for various types of drives; properties of insulated copper wire; fusing current in amperes; capacity of storage batteries; areas and circumferences of circles and data on overhead traveling electric cranes.

Considerable new material has been added to this edition not contained in the 1928 edition. Although this little book deals with the care of European machines and is written from the British viewpoint, most of the material in it will be of assistance to practical men in this country.

TORSIONAL VIBRATIONS

Break Crankshafts

BY E. C. MAGDEBURGER
Aide on Diesel Engines, Navy Department

TORSIONAL vibration of a shaft is a series of quick variations of torque or twisting moment which may be visualized as changes of the tangential force applied a given distance away from the center of the shaft. These torque variations result in corresponding variations of the twist of the shaft, which can be measured by the angular deflection between two sections of the shaft a given distance away from each other, and the latter is a measure of the stress in this portion of the shaft. Changes of torque also cause fluctuations in the rotating speed. Torsional vibration should be of interest to all engineers, both designing and operating, for it results in stress variations that

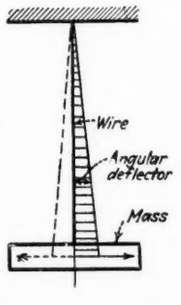


Fig. 1—Angular displacement of a suspended weight

may endanger the shaft and speed variations that may be objectionable to the driven machine.

The cause of torsional vibration is the elasticity of the shaft material, which tends to bring back to their normal state the deflected fibers of the shaft. It was noted long ago that the familiar tuning fork, if deflected slightly, would vibrate at a constant rate. Similarly, if an object be suspended on a wire as in Fig. 1 and this object be deflected from its position by turning it and at the same time twisting the wire, it will, when let loose, begin turning first in one direction, then in another, and so on with continuously reducing amplitudes, or the amounts of deflection, measured on the arc of some constant radius, but always at the same rate, or frequency, of vibration. This type of vibration is called the free or natural vibration. Any shaft system, whether vertical or horizontal, including the masses attached to it, has its own period, or time required to complete one full cycle after once deflected, and consequently has its own frequency, or the number of complete cycles in a given time interval. This interval usually is taken as a minute, so that frequency is expressed in v.p.m., or vibrations per minute. Generally speaking, such a shaft system has, however, several modes of vibration, and therefore several frequencies of natural vibration.

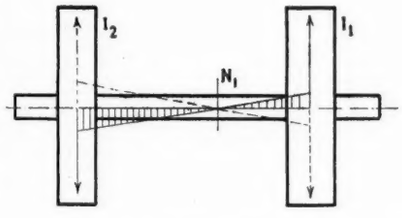


Fig. 2—A shaft system with a single node

A two-mass system can vibrate only by building one node N, as in Fig 2. Node is the name given that plane in which all the particles of the shaft remain stationary. In this case, one mass, shown as a flywheel I_1, will turn in one direction, while the other I_2 turns in the opposite direction. A three-mass system can have two modes of vibration, with one node N, Fig. 3*A*, and with two nodes N_1 and N_2, Fig. 3*B*. Thus a n-mass system will have n-1 modes of vibration.

If, then, a shaft system be subjected to a periodically varying torque, or exciting, also called stimulating, forces

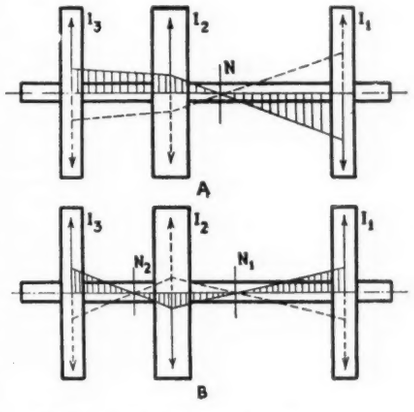


Fig. 3—Modes of vibration in a three-mass system

and the number of changes of the force or the frequency of the exciting force corresponds to the frequency of free vibration of the shaft system, then resonance occurs; that is, the exciting forces will come into synchronism with the free vibration, and minute increments of deflection resulting from the free vibration will be added during each period until the losses will become equal to these increments and the maximum will be reached. This type of vibration is called synchronous torsional vibration and the speeds at which it occurs critical speeds, whereas the number of reversals or periods per revolution of the shaft is called the order of the critical speed. When the exciting force is not in synchronism with the natural vibration of the system, the resulting vibration retains the frequency of the exciting force and is called the forced vibration.

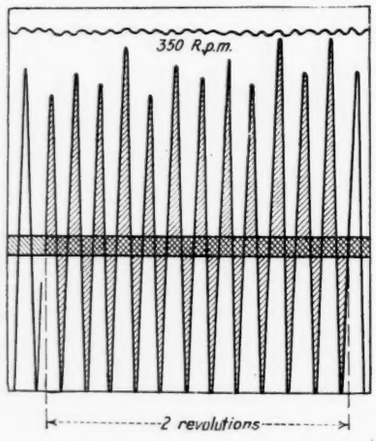


Fig. 4—The torque variation in a high-speed engine

And periodically varying tangential force, or torque, may excite the elastic shaft system to which it is applied and result in synchronous torsional vibration and corresponding critical speeds. Thus the piston pressure of any reciprocating machine varies periodically and may subject the shafting of the machine to synchronous torsional vibration. Various discontinuities in the steam flow through a steam turbine cause periodic variation of the torque, which may produce synchronous torsional vibration. Variations in the shape of gear teeth often are sufficient to cause serious torsional vibration in gear-driven machinery, as has been found in double-reduction gear drives of ships. A ship's propeller may be the cause of such vibration because of the changing resistance to the blade passing the ship's skin. Thus apparently all types of prime movers can experience synchronous torsional vibration and subject the shafting of the whole unit to some more or less violent critical speeds.

Frequency of Vibration Depends on Torsional Stiffness

The frequency of the natural vibration of a shaft system depends upon the torsional stiffness of the shafting and the masses rotating with it. The stiffer the shaft the faster it will want to return to its normal state when once deflected, and thus the higher the frequency of its free vibration. The more mass there is rotating with a shaft, the larger is its inertia and the longer the time the shaft takes to come back to its normal state, therefore the lower its frequency of free vibration. Stiffness is measured by diameter as well as length of shafting and also depends on the material of the shafting. Since most shafting is made of steel, only length and diameter affect its stiffness. An experiment with wires will quickly show that the frequency is higher for shafts of larger diameter and shorter length.

The violence of critical speeds depends upon the relation between the frequency of the exciting force and the frequency of the free vibration of the shaft system. If a shaft system of, say, 1,800 v.p.m. frequency of free vibration be excited by the impulses of a six-cylinder two-stroke-cycle engine running at 300 r.p.m., thus furnishing $6 \times 300 = 1{,}800$ impulses per minute, a resonance will occur and a six-order (six impulses per revolution) critical speed will be evident. If the same engine were run at 150 r.p.m., twelve changes of torque of a twelve-order critical speed would be recorded, corresponding to $12 \times 150 = 1{,}800$ v.p.m. of its free vibration despite the fact that only six cylinders fire per revolution. Such speeds are called *major critical speeds* because the exciting impulses are of exactly the same *phase* as the free vibration; that is, they occur either every vibration, as in the above six-order, or every other vibration, as for the twelve-order. Thus major critical speeds are of such an order as is a multiple of the number of exciting impulses per revolution. For an eight-cylinder four-stroke-cycle oil engine the major critical speeds will be of 4, 8, 12, 16,

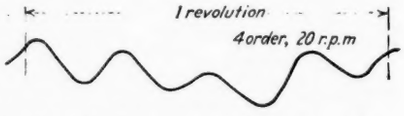


Fig. 5—Torsiograph from a triple-expansion engine

etc., order. All other critical speeds are called *minor critical speeds* and have a phase difference with the exciting impulses, as will be shown later.

Instruments to Measure Torsional Vibration

As has been noted already, torsional vibration results both in changes of twist or angular displacement of two given shaft sections and changes of speed of the vibrating shaft. These two characteristics of torsional vibration served as the foundations of two instruments designed to measure and to study it. One built by Dr. H. Frahm as the result of his studies of torsional vibration, which began as early as 1902, is made to measure the fluctuation of angular displacement of two sections of the shaft about eighteen inches away from each other and therefore answers directly the question of stress in this portion of the shaft, and that is, after all, what interests the engineer first of all—the shaft stresses. The other came into being during the World War and resulted from the labors of another German engineer, Dr. J. Geiger, who developed it at the works of the M.A.N., the foremost builder of high-speed Diesel engines for the U-boats. This

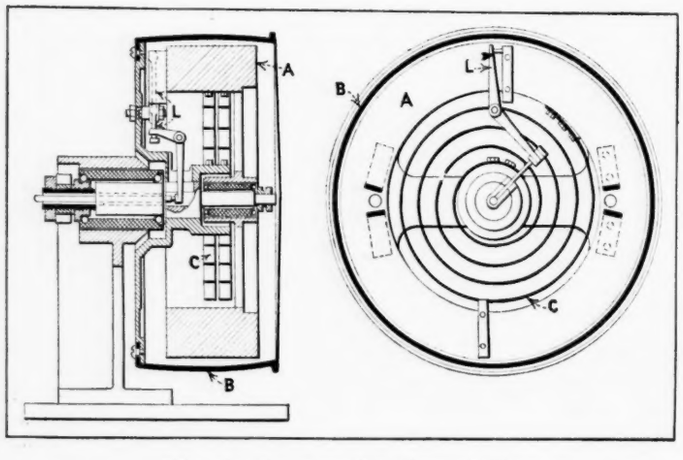


Fig. 6—Cross-section through the Geiger torsiograph

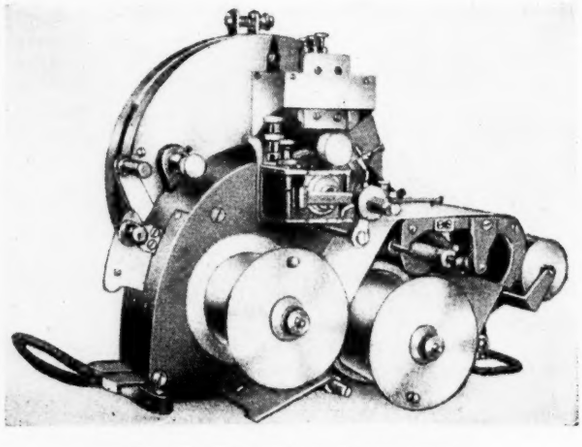


Fig. 7—The Geiger instrument assembled

apparatus is based on the principle of the seismograph used to record earthquakes and records speed variations of the part of the shaft from which it is driven by a special non-stretching belt. Thus this gives an indirect answer to the question of shaft stress and its ability to withstand it, and requires considerable additional calculation to ascertain these stresses. But owing to the fact that the Geiger torsiograph is readily obtainable commercially, it became widely used, whereas Frahms apparatus is used only by his firm of shipbuilders—Blohm & Voss, of Hamburg.

The Geiger instrument, Figs. 6 and 7, has a light aluminum belt pulley *B*, inside which runs a heavy flywheel *A*. Both the pulley and flywheel run independently on ball bearings, but are connected to each other by means of a calibrated volute spring *C*. When the instrument is in action, the pulley *B* is belt-driven from the shaft under examination and reproduces the speed irregularities of the shaft, while the flywheel *A* tends to run at uniform speed. It follows that there will be angular variations between the pulley *B* and flywheel *A;* these are transmitted by means of the levers *L* to a tracing pen which traces a diagram on a continuously moving paper strip.

Operation at a critical speed results in deflections due to the free vibration adding to the deflections from the exciting torque impulses until internal friction in the shaft material and the external friction, such as that in the shaft bearings and that due to the piston thrust, will consume the equivalent of these torque impulses and the growth of the deflections will stop, thus reaching their maximum. The maximum amplitude of vibration depends upon the mode of vibration, and the order of the critical and upon the makeup of the system; that is, the stiffness of the shaft and the total moment of inertia of the masses.

Naval Propelling Plants (Variable Speed)

Fig. 4 shows the torque variation and consequently changes in angular displacement and shaft stresses of a 6 order 1 noded critical speed taken by Doctor Frahm on a high-speed six-cylinder, 16.56x17.75-in., four-stroke-cycle U-boat engine turning at 450 r.p.m. direct connected to a flywheel type of generator. Here the stresses are ten to eleven times those required to transmit the useful torque, shown by the shaded portion *A*. This record shows large negative torque components which result in chattering and noise of all gears and couplings of the jaw type employing clearance between the driving and the driven members, with inevitable excessive wear, especially if these parts are near the node. A submarine engine crankshaft broke through main-bearing oil holes—a typical result of operation in a torsional critical speed. This shaft is shown in the headpiece.

A record taken by a Geiger torsiograph on a four-cylinder triple-expansion steam naval engine when running about two revolutions away from the maximum of this four-order one-noded critical speed, is reproduced in Fig. 5. The speed variation computed from this record shows that the speed varied from a minimum of 68½ r.p.m. to a maximum of 72½ r.p.m., while a mean speed of 70 r.p.m. was being maintained. This record was taken after the outboard coupling of the propeller shaft had failed and had been renewed, which happened after about 500 hours of operation right at the maximum of this four-order one-noded critical. This goes to show that the critical speed could not have been seen or heard by the operating personnel, and the breakage of the shaft coupling came as a complete surprise to them.

Shaft Failures on Naval Steam Engines

A considerable number of shaft failures of former years on various naval steam engines could have been explained by torsional vibration. The reason why naval engines suffered most lies in the necessity to operate propelling plants of naval vessels at any speed from the lowest to the full power speed to meet tactical requirements, whereas a stationary engine operates at the same speed all the time, and there is, therefore, much less chance to hit a critical speed. However, at least two sets of large multi-cylinder oil engines driving generators, recently built to government order, have suffered much from torsional vibration.

A large six-cylinder two-stroke-cycle Diesel engine on the test stand broke several of the arms of the flywheel type of generator it was driving. These arms were made heavier, but when the unit was started again the generator arms cracked after a short time. Torsional records were then taken and showed the dangerous six-order critical at that speed. The trouble was eliminated by making suitable changes in the shaft, so that no synchronism at the normal engine speed was possible, and the engines have operated successfully since for about three years. Thus nine large flywheel armatures were made for the three units ordered.

Diesel Engine Shafts Break

The speed of certain medium-sized six-cylinder four-stroke-cycle Diesel engines driving generators in four army dredges, happened to be too close to a critical speed of the six order, and more than nine shafts were broken before torsiograph investigation was made and various changes incorporated in the new shafts at a cost of about two million dollars. Subsequently, one of the operators, when the load was light, decided to save his engines by operating them at a slower speed. Six hundred hours' operation at this speed, which again was in a critical range, cost him an engine crankshaft. A recent note in *Power* by an engineer operating an oil-engine-driven ammonia compressor in an ice plant suggested that during winter when the load is light, the engine speed should be lowered. To change the engine speed without full knowledge of the critical speeds of such a unit is extremely dangerous, as the foregoing example has shown.

Furthermore, synchronous torsional vibration causes much trouble by heating of bearings at or near the node and by welding hubs of couplings and other parts keyed to the shaft to the latter surface, so that removal is sometimes impossible and hubs must be cut apart. Of similar nature is the effect on coupling bolts. Sometimes it is impossible to remove them without using powder guns.

Much trouble has been experienced from the inability of paralleling oil-engine-driven generators and from irregularities of engine speed so serious as to cause flickering of electric lights. These look very much like symptoms of torsional vibrations, and no such trouble need exist now when this phenomenon is thoroughly understood.

[*In a second article the author will show how to determine critical speeds and to eliminate their danger.*—Editor.]

Oxyacetylene Welding of Refrigeration Apparatus

THE following is quoted from a recent report of the Oxyacetylene Committee of the International Acetylene Association.

"American manufacturers of refrigeration apparatus were among the first to recognize the value of modern welding processes applied to the fabrication and assembly of refrigeration components.

"The necessity for construction absolutely tight under pressure of ammonia, carbon dioxide and other gases had resulted in early designs using blacksmith's forge welds, and these forge welds still continue to be used to some degree years after gas welding has been introduced and found satisfactory. One reason for the persistent use of forge welding is found perhaps in certain city ordinances.

"Prime requirements in refrigeration apparatus are pressure container strength and tight joints. Receivers, accumulators, coolers, pipes, coils and headers must be amply strong to resist the normal internal pressures applied, and all joints must remain tight under every normal condition of service.

"Before the advent of oxyacetylene welding in the United States, about 1905, refrigeration seams and joints were made up with forge welds, rivets, screw threads, flanges, gaskets and so forth. Naturally, when oxyacetylene welding was established as a commercial process, it was taken up by progressive builders of refrigeration machinery and applied in the fabrication of their apparatus with the object of simplifying construction and making operation more dependable.

"Designers of refrigeration pressure containers find that gas welding gives them important advantages with regard to weight, durability, cost and ultimate strength. Oxyacetylene-welded construction has worked out much to the advantage of manufacturer and user.

Fitting the Coal to the Plant

By T. A. MARSH

Western Engineer, Combustion Engineering Corporation

Provide means for measuring coal and water; establish a cost system based on 1,000 pounds of steam; including all items; select the coal that really makes the cheapest steam —these are some of the suggestions offered in the paper read before the Indiana Fuel Conference, Purdue University, extracts from which are here presented.

HOW to select the proper coal for any plant can be stated in these eight words, "Use the coal that makes the cheapest steam." Every plant should have some means of measuring water or steam and of weighing coal so that the amount of coal used per 1,000 lb. of steam can be determined. This is the unit of comparison, and the cost figures should be kept on a daily basis and rechecked in a monthly summary. Data should be available that will make possible comparison of the cost of fuel, labor and maintenance.

Fuel cost per 1,000 lb. of steam will vary with the quality of the coal, the cost per ton and the efficiency of operation. When the unit cost is known, comparison of coal may be made and means may be discussed for improving unsatisfactory conditions. Tests can then be made to determine how costs can be lowered with the present equipment, what coal is most economical, and the additional equipment that can be justified.

Purchasing of the coal is one of the most important items in the production of cheap steam. Sometimes the cheapest coal on the market is the one that will keep the fuel bills down, and at the other times it is the highest-priced coal.

MANY FACTORS INVOLVED

The following are items that every coal user should have before him and study before making his choice: Ability to carry the plant load; reliability of supply; mine preparation; ability of producer to give uniform quality; transportation facilities; adaptability to stoking equipment; service from the coal company; maintenance cost of furnaces and stokers; fusion temperature of the ash; labor of firing; responsiveness to meet sudden load demands; smokelessness; cost of ash removal; sulphur content.

Throughout the country there are coals that are always disproportionately cheap because of their firing characteristics. Either they contain a high percentage of ash or clinker easily, thereby causing increased labor in cleaning the fires and in ash removal. Such coals should be avoided, if the labor cost increases more rapidly than the purchase price decreases.

Then there are coals that are relatively cheap on a B.t.u. basis, but are of a class that causes high maintenance of grates and furnace. These coals also should be avoided if maintenance charges and the loss due to boilers out of service are to be kept within reason.

Purchasing coal to produce the cheapest steam becomes a problem only partly dependent upon the number of B.t.u. obtained per dollar. Considering all the items enumerated, the method of approaching this problem is to consider the entire fuel supply tributary to the locality in question. From these select the coals that can be supplied in sufficient quantity and with the assurance of continuity of supply from reputable coal companies. If storage is involved, the coals that can be stored properly must be given preference, since the loss of fuel or of heat by storage, fire or otherwise, is a sure road to increased steam cost.

COMPARATIVE TESTS OF FUELS

The analysis usually will resolve itself into a choice from among three or four coals. It is unnecessary to select more than one or two coals from the district or seam to determine what can be done with that particular kind of fuel. To guard against low capacity or shutdowns from maintenance troubles or other causes, trial purchases of these coals should be of limited amounts. They should be burned separately in the regular routine of daily plant operation for a month or more, accurate records being kept during this period in order to arrive at the actual day-in and day-out peak load, average load and banking performance, under no special supervision, but with the regular operating organization and routine.

SUITABLE ACCOUNTING SYSTEM NEEDED

Such periods of operation will provide opportunities for reasonable study of maintenance, labor in firing and ash handling. In addition, they will cover a sufficient quantity of coal to give a good indication of how the fuel actually runs on monthly averages, as compared with samples supplied for test purposes.

There should be a suitable accounting system, so that the cost of steam production may be charged with all items. For each coal under a thirty-day test a separate analysis of cost should be made, giving more weight to observed maintenance than to actual figures, since a thirty-day period is not long enough to determine this item accurately.

Engineers have devoted so much thought to developing high technical efficiencies that in many instances they have lost sight of the ultimate aim—high dollar economy. Many examples can be cited where capital charges and operating costs more than offset the advantages of higher efficiency from the apparatus. There is also to be mentioned that class of apparatus that gives high gross efficiency, but entails auxiliary and operating losses that reduce the net or useful work to a point where the net efficiency is impaired.

Oxyacetylene Welding for Heating Systems

THE present status of oxyacetylene welding in the construction of heating and ventilating systems is summarized in the following quotation from a recent report of the Oxyacetylene Committee of the International Acetylene Association.

"While the presence of cylinders and oxyacetylene equipment on all large building jobs has long been commonplace, the casual observer can hardly realize the rapidity with which the process has grown or to how many phases of construction it has extended in a very short period.

"One of the most important steps it has taken is that of welding pipe joints for high-and low-pressure steam and for water and gas service in all types of buildings where extensive piping systems are used.

"Oxyacetylene welding is gaining headway in this field principally because of the marked superiority of a welded joint over a mechanical joint, thus insuring greater freedom from leakage and adding greatly to the life of the installation. The welded system also gives greater efficiency because of better circulation and has the added advantages of economy of space.

"The foregoing advantages being almost immediately obvious, the most natural question in the contractor's mind is that of comparative costs. It is safe to say that for any but the smaller sizes of pipe the cost of welded joints is less than that of mechanical joints and the economy is greater as the size of pipe increases.

"The simplicity and portability of the equipment and the comparatively short time in which the pipefitter can be trained to do acceptable pipe welding have appealed to the contractors in this industry and have encouraged many of them to undertake the process on a small scale until they have had an opportunity to observe its full worth. While it was only natural that the unions, as well as contractors, designing engineers and architects, would move cautiously in the adoption of a practice that is so radically different from the methods long in vogue, great credit should be given the progressive members of their organizations for their ability to recognize the advantages of welding in the plumbing and heating field and for their co-operation in revising specifications and in accepting the assistance of the oxyacetylene industry in training operators to perform the work."

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

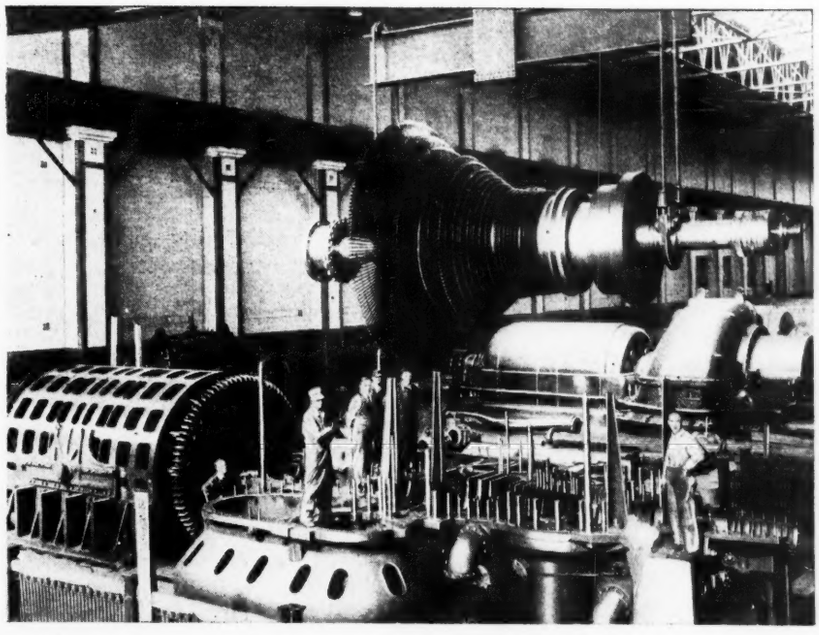
Canadian Supreme Court In Partial Decision on Hydro Rights

Provincial vs. Dominion Jurisdiction Still Unsettled

IN A judgment handed down at Ottawa on Feb. 5 in the water-power rights case which was argued last October, the Supreme Court of Canada calls attention to the impracticability of answering in a precise manner most of the questions submitted to it. The Court does, however, definitely declare that the provinces have the title to use the beds of navigable rivers, and even there exception is made with respect to special rights vested at Confederation or by subsequent legislation. The whole matter will probably come up for discussion at the forthcoming session of Parliament, after which it will be referred to the Privy Council in England for final decision.

In order to settle the relative rights of the Dominion and provincial governments with regard to water powers, made available or in connection with works for the improvement of navigation, the Dominion government submitted a series of ten questions to the Court. Some of the answers favor the contentions of the federal government, while others appear to support the submissions of the provincial governments. With regard to a number of the questions, however, the Court decided that owing to the form in which they were submitted it was impossible to give precise or even intelligible answers.

Questions that are left unsettled concern the power of the Dominion authorities to use or occupy provincial navigable rivers without the consent of the province or without compensation; the respective rights of the parties with regard to water powers created or made available on works for the improvement of navigation by the Dominion since Confederation; the rights with respect to water powers in boundary waters, and the right of the provinces to use and develop water powers within the province, even though navigation is not prejudiced. The Court took the position that the questions submitted were too abstract to permit of more than indefinite answers. It will be necessary to submit concrete cases to clarify the situation.



ROTOR of new 60,000-kw. turbine being lowered into its casing at the Lakeside plant of the Milwaukee Electric Railway and Light Company, Milwaukee, Wis. The machine was built by the Westinghouse Electric & Manufacturing Company. The rotor alone weighs 116,000 lb.

N.A.P.E. Annual Convention Date Announced

According to an announcement just made, the annual convention of the National Association of Power Engineers will be held this year in Chattanooga, Tenn. The dates will be Sept. 9 to 13. As usual, an exhibit of mechanical equipment will be conducted in conjunction with the convention, under the name of the "1929 Power and Mechanical Exhibition." Manufacturers wishing to exhibit equipment at the exhibition are urged to communicate with F. N. Chapman, secretary of the National Exhibitors Association, 5900 Kennerly Ave., St. Louis, Mo.

Record breaking attendance is expected, both at the convention and exposition, which are to be held in the South for the first time.

Hydro Development on New River Planned

An appropriation of $11,000,000 for the Appalachian Electric Power Company's hydro-electric project on New River, near Radford, was voted by the company's directors at a recent meeting in New York City.

The plant will have an installed capacity of 80,000 kw., and will be among the largest power developments in the South, according to the information which came from an authoritative source. It will be by far the largest power development in Virginia, and the dam to be erected will impound the largest body of water between North Carolina and New York, it is believed. The lake will be 21 mile long.

Hydro Project in Mexico

Following the recent purchase by the Electric Bond & Share Company, of New York, of the holdings of the Tampico Electric Company and other large electric light and power interests in Mexico, a statement by L. P. Hammond, vice-president of the first-named company, says that it will construct a 50,000-hp. hydro-electric plant at the Micos Falls, in the State of San Luis Potosi. Construction will be started in February. Transmission lines will be constructed to San Luis Potosi, Monterey, Saltillo, Mexico City, Tampico and a number of smaller communities and mining districts. The cost of the project will be approximately $10,000,000.

Eighth National Power Show Date Announced

The International Exposition Company, of New York City, has announced the Eighth National Exposition of Power and Mechanical Engineering, to be held in the Grand Central Palace, New York, Dec. 2 to 7, 1929. The announcement is accompanied by a printed registration of the visitors who attended the seventh annual show held at the Palace, Dec. 3-8, 1928. This list was compiled with great care in order to convey to prospective exhibitors for 1929 an idea of the number of people who attended the show, and to give figures on which the 1929 attendance can be estimated. The list also serves as a check by which exhibitors may verify the addresses of those with whom they made business contacts at the seventh annual show.

The list was compiled in a conservative manner, and only the names of visitors who registered were included. The exhibitors themselves were not listed. It was felt that in this way the compilation would be of the greatest value for future use.

Industrial Heating Subject of Slogan Contest

Seven prizes, totaling $500, will be awarded by the National Electrical Manufacturers Association and the National Electric Light Association for the best slogans to promote the use of electric heat in industry, it has been announced. The first prize will be $250, second $100, third, $50, and four of $25 each.

According to the joint committee in charge of the contest, slogans should be broadly descriptive of the possibilities and advantages of electric heat in industry. Each slogan is to be accompanied by an analysis of 100 words or less. Manuscripts or requests for information should be addressed to "NEMA-NELA Slogan Contest, National Electrical Manufacturers Association, 420 Lexington Ave., New York City." The contest will close May 30.

Boiler Figures for Past Three Years Given

Among the reports given at the meeting of the American Boiler Manufacturers Association at Cleveland, Feb. 5, was one, presented by C. O. Meyers, secretary of the National Board of Boiler and Pressure Vessel Inspectors, giving the figures for the number of A.S.M.E. Code boilers registered in each class for the calendar years 1926, 1927 and 1928. The figures given by Mr. Meyers were as follows:

	1926	1927	1928
Up to 50 sq.ft.	13,272	11,903	12,398
60 to 500 sq.ft.	4,299	3,334	2,860
510 to 2,000 sq.ft.	2,007	2,031	1,943
2,010 to 5,000 sq.ft.	668	428	469
5,010 sq.ft. and above	499	364	383

*Spot * News*

SEVEN LANGUAGES *are spoken by the 'phone girls who work for Chicago's public utility company. You can order a new fuse plug in Persian, probably, or get the prevalent power rate translated into Sanskrit under this arrangement. A kilowatt-hour by any other name is still a kilowatt-hour, even in Chicago.*

* * *

THE INTERNATIONAL PAPER COMPANY, *through its subsidiary, the Gatineau Power Company, has in a little more than three years developed a total of 436,000 hp. on the Gatineau River. Farmers Rapids, Chelsea and Paugan Falls are the contributing elements, and all three are slated for further development, to bring the final total from this one river to 562,000 horsepower.*

* * *

A CAMPAIGN *for elimination of small wastes during Management Month, April of this year, is being planned by a joint committeee of the Management Division of the American Society of Mechanical Engineers and the Local Sections of the Society. Remarkable savings have been made by elimination-of-waste campaigns in the past. These campaigns conducted within plants made use of clever exhibits to win the support of the employees.*

* * *

THE METROPOLITAN SECTION *of the A.S.H. & V.E. listened on Feb. 18 to a talk on coke manufacture, by W. R. Morris, of the Seaboard Coke Company.*

* * *

WAUKEGAN, WISCONSIN, *takes pride in announcing its new pumping and filtration plant, capable of handling 20,000,000 gal. a day. The plant consists of electrically driven units installed in duplicate, from the smallest bolt to the largest pump. One side alone can handle Waukegan's present needs comfortably.*

* * *

FIFTY *municipally owned power plants have gone out of business in Iowa in the last five years. Public-utility interests consider this to be typical of the movement away from public ownership throughout the country.*

Chicago Engineers Discuss Safety

The Chicago chapter of the National Association of Practical Refrigerating Engineers recently held a meeting in Chicago at which a symposium on safety was made the feature of the evening. Several prominent speakers addressed the gathering, the principal topic being the matter of safety to employees in refrigerating plants. Dean Keefer, chief engineer of the National Safety Council, pointed out that there was as much of an accident problem in the refrigerating industry as in any other. Paul Van Cleef discussed the work of the Chicago Safety Council and pointed out where the reponsibility for safety work in industry should lie. W. M. Oler, vice-president of the American Ice Company, of New York City, warned against regarding safety work as a special drive, only temporary in character, and pointed out that it would be most effective when it had become habitual. Mr. Keefer later showed some motion pictures bearing on safety work in industry, and the meeting was concluded with a discussion in which several of the members joined.

Civil Service Examinations For Hydro Engineers

The United States Civil Service Commission announces the following open competitive examinations:

Hydro-electric engineer, $3,800 to $4,400 a year; associate hydro-electric engineer, $3,200 to $3,700 a year; assistant hydro-electric engineer, $2,600 to $3,100 a year.

Applications for these positions must be on file with the Civil Service Commission at Washington, D. C., not later than March 13. The examinations are to fill vacancies occurring in the Engineer Department at Large, War Department, throughout the United States, and in positions requiring similar qualifications. At present there is a vacancy in the associate grade in the Chattanooga, Tenn., District of the Engineer Department.

The duties are in connection with the investigation and complete study of streams to determine power, navigation and flood-control possibilities. This will include a study of potential power sites and regulating reservoirs of a particular district, available for hydro-electric development, to determine their value as individual developments and as parts of a comprehensive scheme of combined steam and hydro-electric superpower development for the entire territory within economical transmission radius. Embraced in the work will be the following: Selection of sites, tentative designs and estimates of cost, field reconnaissance, a study of transmission and marketing of power, final study, design, preparation of plans, and estimate of cost.

Full information may be obtained from the United States Civil Service

Commission, Washington, D. C., or from the secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city. Competitors will not be required to appear in person for examination.

U. of Illinois Announces Research Assistantships

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen Research Graduate Assistantships in its Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to gradutes of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a Research Graduate Assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

The Engineering Experiment Station, an organization within the College of Engineering, was established in 1903 for the purpose of conducting investigations in the various branches of engineering, and for the study of problems of importance to engineers and to the manufacturing and industrial interests of the State of Illinois. Research work and graduate study may be undertaken in all of the principal branches of engineering and science.

Aberdeen, Wash., Plans Hydro Plant

The City of Aberdeen, Wash., has filed with the state hydraulics supervisor data additional to those contained in previous preliminary filings for water rights on the Wynooche River in Gray's Harbor County. Aberdeen desires to launch a power and municipal supply project, to cost $5,200,000.

This undertaking, which may be under construction by Jan. 1, 1931, in the event that the permits are issued, would enable Aberdeen to maintain an electric power plant with an estimated output of 35,000 hp. The power house would be immediately adjacent to the proposed Weatherwax Dam, which would be built in the upper Wynooche district, 14 miles northeast of Humptulips. A concrete dam 265 ft. in height with a 1,100-ft. top measurement and a bottom length of 120 ft., is contemplated. Between two and three years would be needed for its completion. The hydraulics supervisor has also received an application for water rights on the Humptulips River, in the same county, from R. H. Stock of Aberdeen, who wishes to develop 2,000 horsepower.

More Spot * News

SQUEEZING RUBBER *out of coal is the latest German scientific marvel. However, it isn't as simple as it sounds and it costs a good deal to do it. Thus, for some time to come synthetic balloon tires and raincoats will hardly come from the coal pile.*

* * *

WASTE PRODUCTS *are coming more and more into favor as sources of valuable raw materials.. Even the ubiquitous cornstalk, says the United States Chamber of Commerce, contains everything from alpha cellulose to xylose. Perhaps xylose may not be thrown away in every industrial plant, but undoubtedly something else is, if only heat. Reclamation is the watchword of the day.*

* * *

WATER PUMPING SYSTEMS *are operated by electricity on 12,846 farms in Illinois. The old oaken bucket is ready for the museum at last!*

* * *

ONE BILLION GALLONS *a day will be the condensing water requirement of the new Ford power plant at River Rouge. A two-mile tunnel will carry this flood under the city, and though the Ford company will build and operate it, Detroit will receive the title to the property. It is not stated just what use the city fathers may be able to find for the tunnel or the billion gallons.*

* * *

AN IMPROVED METHOD *of fluid velocity measurement has been devised by Profs. H. E. Hartig and H. B. Wilcox under the experimental program of the A.S.M.E. Special Research Committee on this subject. The new method depends upon measuring differences in audio frequencies, the fluid velocity being proportional to the frequency difference.*

* * *

THIRTY-FOUR AND A HALF *million dollars will be spent by the utilities associated with the United Gas Improvement Company, of Philadelphia, during 1929, according to John E. Zimmermann of that organization. The sum will be fairly evenly divided between gas and electric properties.*

Coolidge Dam Reservoir Filling

Progress on the Coolidge Dam in Arizona is reported by the secretary of the Arizona Utilities Association as follows: There is now 55 ft., or approximately 16,000 acre-feet, of water stored behind the Coolidge Dam. It forms a lake about 5½ miles in length lying in the beds of the Gila and San Carlos Rivers. When the waters rise to a height of 64 ft. they will flow through penstocks at the dam and the generation of electric power will begin.

Sixty-four feet of water will mean that the lake will contain 25,000 acre-feet, the minimum which will thereafter be stored. No power can be generated with a less amount of water behind the structure. It is expected that this minimum will soon be reached. The storage capacity of the Coolidge reservoir is 1,285,000 acre-feet. When this capacity has been reached, the lake formed will be 22 miles long and about 5 miles wide. It will back the water up to within 4 miles of the town of Rice on the San Carlos River and to within about the same distance of Bylas station on the Gila.

In the News

THORNTON LEWIS

was elected president of the American Society of Heating and Ventilating Engineers at its 35th annual meeting. Mr. Lewis served his apprenticeship with the Buffalo Forge Company, and was later associated with the firm of Lewis, Robinson and Gant, and with the Carrier Air Conditioning Company, and the Du Pont Company. In 1921 he organized the York Heating and Ventilating Corporation, of which he is now president and general manager.

Coming Conventions

American Institute of Electrical Engineers, annual summer convention, Swampscott, Mass., June 24-28; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Institute of Refrigeration, at Washington, May, 1929. Louis Baron, secretary, 203 West 13th St., New York City.

American Oil Burner Association, annual convention, Hotel Pennsylvania, New York City, April 9-11, 1929. For information, address the headquarters of the Association at 420 Madison Ave., New York City.

American Society of Heating and Ventilating Engineers, annual summer meeting, Big Wind Inn, Lake of Bays, Ontario, Can., June 27-29. F. L. Hutchinson, secretary, 29 W. 39th St., New York City.

American Society of Mechanical Engineers, spring meeting, Salt Lake City, Utah, July 1-4, 1929. Rochester regional spring meeting, Rochester, N. Y., week of May 13. Calvin Rice, secretary, 29 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers, 25th annual convention, Pittsburgh, Pa., June 17-22, 1929. A. A. Stewart, secretary, Pittsburgh Steel Co., Monnessen, Pa.

Canadian Electrical Association, annual convention, to be held June 19-21, at St. Andrews-by-the-Sea, N. B. H. M. Lyster, secretary, Power Building, Montreal, Que.

Master Boiler Makers Association, at Atlanta, Ga., May 21-24. H. D. Vought, secretary, 26 Cortlandt St., New York City.

National Association of Power Engineers, 47th annual convention, Chattanooga, Tenn., Sept. 9-13. Fred Raven, secretary, 417 South Dearborn St., Chicago, Ill.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

Twelfth Exposition of Chemical Industries, New York City, May 6-11. For information address Publicity Department of the Exposition, Grand Central Palace, New York.

World Engineering Conference, Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon, Kogyo Club, Morunouchi, Tokyo.

Obituary

MATTHEW GRISWOLD, who retired as manager of the Erie (Pa.) works of the General Electric Company on Jan. 1 of this year because of ill health, died at his home in Erie on Feb. 10. Mr. Griswold was born in Erie in 1866, and was graduated from Sheffield Scientific School, Yale, in 1888. After two years of post-graduate work he received the degree of M. E. Upon leaving college he became associated with the Griswold Manufacturing Company, of which he served as president for a number of years. On Nov. 11, 1911, he severed his connection with the Griswold Manufacturing Company to become acting manager of the Erie Works of the General Electric Company. He was made manager of the plant on Dec. 12, 1912.

Personals

J. E. MCDONALD has resigned as sales manager of the Edward Valve & Manufacturing Company, East Chicago, Ind., to become vice-president of the B. Floersheim Company, Incorporated, Pittsburgh, Pa.

C. F. WEIGEL has been elected vice-president and general manager of the Hedges-Walsh-Weidener Company, Chattanooga, Tenn., a subsidiary of the Combustion Engineering Corporation.

GEORGE W. FULLER, consulting hydraulic engineer and sanitary expert for the Fuller & McClintock Company, New York City, was elected president of the American Public Health Association at the recent convention of that body.

CHARLES FOSTER, consulting engineer, Duluth, Minn., has been appointed a member of the Minnesota State Board of Architects, Engineers and Land Surveyors.

A. J. SWEET, formerly in consulting practice in Milwaukee, Wis., has become associated with the Westinghouse Lamp Company, East Pittsburgh, Pa., in its commercial engineering department.

HAROLD F. SHEPHERD, formerly Diesel engineer for the Bessemer Gas Engine Company, Grove City, Pa., has accepted a similar position with the C. & G. Cooper Company, Mt. Vernon, Ohio, builders of M.A.N. solid injection Diesel engines.

With the Society Sections

A. S. M. E., Boston Section. Meeting, Feb. 27. Subject: "The Trend in Steam Power Station Design," by V. E. Alden, Stone & Webster Engineering Corp., Boston, Mass.

A. S. M. E., Knoxville Regional Meeting, Mar. 21-23, 1929. Technical program and trips to points of interest.

A. S. M. E., Philadelphia Section. Meeting Mar. 26. Subjects: "Resume of High Steam Pressures as Used in Industrial Plants," speaker to be announced later. "Twelve-hundred Pound Holland Station of the Pennsylvania and New Jersey Power System," by E. M. Gilbert, W. S. Barstow Management Association, Reading, Pa.

American Water Works Association, Montana Section. Annual convention, to be held April 4 and 5 at Great Falls, Mont.

American Water Works Association, Florida Section. Meeting, April 10, at Jacksonville, Fla. Subject to be announced later.

Engineers Club of St. Louis. Meeting Feb. 27. Subject: "Refrigeration and Ice Making," by George B. Bright, pres., A.S.R.E. Meeting, Mar. 13. Subject: "The Automatic Control of Combustion in Boiler Furnaces," by Mellville Stein, Leeds and Northrup Co., Philadelphia, Pa.

Second Annual Indiana Fuel Conference, at Purdue University, Lafayette, Ind., April 4-5.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard...	New York.....	$2.35@$2.40
Kanawha.....	Columbus.....	1.25@1.60
Smokeless.....	Cincinnati.....	2.15@ 2.25
Smokeless.....	Chicago.....	2.25
S. E. Kentucky...	Chicago.....	1.35@ 1.60
Steam.....	Pittsburgh.....	1.55@ 1.75
Gas Slack.....	Pittsburgh.....	.90@ 1.10
Big Seam.....	Birmingham....	1.25@ 1.50
Anthracite (Gross Tons)		
Buckwheat.....	New York.....	$2.75@$3.00
Barley.....	New York.....	1.00@ 1.50

FUEL OIL

New York—Feb. 21, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4¾c. per gal.; 36@40 deg., furnace, tank-car lots, 6½c. per gal.

St. Louis—Feb. 14, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.40 per bbl. or 42 gal.; 26@28 deg., $1.45 per bbl.; 28@30 deg., $1.50 per bbl.; 30@32 deg., $1.55 per bbl.; 32@36 deg., gas oil, 4.776c. per gal.; 38@40 deg., distillate, 5.73c.

Pittsburgh—Feb. 11, f.o.b. local refinery, 30@34 deg., fuel oil 5c. per gal.; 36@40 deg., 5¼c. per gal.

Philadelphia—Feb. 8, 13@19 deg., $0.95@$1.02 per bbl. or 42 gal.; 22 deg. plus, $1.47@$1.53 per bbl.; 26@30 deg., $2.00@$2.06 per bbl.

Cincinnati—Feb. 18, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Feb. 16, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 70c. per bbl.; 26@30 deg., 90c. per bbl.; 30@32 deg., $1.20 per bbl.

Boston—Feb. 18, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.5c. per gal.; 28@32 deg., 5.6c. per gal.

Dallas—Feb. 16, f.o.b. local refinery, 26@30 deg., $1.25 per bbl. or 42 gallons.

Business Notes

THE PREST-O-LITE COMPANY, New York City, announces that a new Prest-O-Lite acetylene plant, at 1241 North McLean Boulevard, Memphis, Tenn., began operations Dec. 19, 1928. This plant, which is the 36th of the Prest-O-Lite chain, will supply near-by industries with dissolved acetylene for oxy-acetylene welding and cutting.

THE LADD EQUIPMENT COMPANY has recently been formed with general offices in the Farmers Bank Building, Pittsburgh, Pa. The officers of this new organization are: George T. Ladd, president and treasurer; Robert E. Chew, vice-president and general manager; George F. Bright, Jr., secretary, and James N. Burke, sales manager. All these men have been identified with power plant engineering and equipment in the Pittsburgh district for a number of years. The Ladd Equipment Com-

pany is acting as sales engineering representative for a limited number of companies not only in the Pittsburgh district but throughout the country.

THOMAS E. MURRAY, INCORPORATED, 88 Lexington Ave., New York City, announces the opening of a branch office in the Eaton Tower, Detroit, Michigan. G. H. Kuechler will have charge of the office.

THE BAILEY METER COMPANY, Cleveland, Ohio, announces the appointment of R. V. Knapp as manager of its Chicago office at 53 W. Jackson Blvd.; C. M. Kunkel as manager of its Houston office at 1201 West Gray Ave., and H. H. Gorrie as acting manager of its San Francisco office at 402 Sharon Building.

CUTLER-HAMMER, INCORPORATED, Milwaukee, Wisconsin, announces that it has acquired the business of the Trumbull Vanderpoel Electric Manufacturing Company, of Bantam, Conn., which will be operated as a subsidiary under its present name.

TRADE CATALOGS

REFRIGERATING MACHINERY — In an attractive 70-page bound volume entitled "Seventy-five Years of Progress," the Frick Company, Inc., Waynesboro, Pa., looks back over the history of its organization since 1853. A description and many interesting photographs of the numerous types of refrigerating equipment developed by this company are included.

WELDED PRESSURE VESSELS—Power engineers will find much of interest in Bulletin No. 507, recently issued by the A. O. Smith Corporation, Milwaukee, Wis. Dealing specifically with autoclaves and jacketed vessels, electrically welded by the special Smith process, this bulletin gives information of value to any engineer interested in the design and construction of pressure vessels for any purpose.

ELECTRIC WIRING DEVICES—Bulletin 2126, just issued by the Crouse-Hinds Company, Syracuse, N. Y., covers in eight pages the company's line of condulets, connectors and couplings for electric wiring. The information is presented in tabular form, with illustrations of each device and specifications and prices in parallel columns.

CONTROLLERS—A new four-page leaflet has been issued by the Electric Controller & Manufacturing Company, Cleveland, Ohio, showing an innovation in panel-mounted control devices. The leaflet contains illustrations and general descriptive text.

WATER SOFTENERS—The Paramount Water Softener Corporation, New York City, has published a four-page leaflet describing its apparatus for zeolite water softening. An illustration and description of the apparatus is given.

DUMPING GRATES — Eight pages of illustrations, diagrams and blueprints make up a bulletin just issued by the McClave-Brooks Company, Scranton, Pa., describing its Type 4-A anthracite dumping grate.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Calif., Chualer—Salinas Valley Ice Co., 124 Soledad St., Salinas, plans the construction of a cold storage plant and packing sheds here. Estimated cost $1,000,000. Private plans.

Calif., Los Angeles — Adohr Creamery Co., 1801 La Cienega Rd., is having plans prepared for the construction of a 96 x 107 ft. power house. Morgan, Walls & Clements, Van Nuys Bldg., are architects.

Calif., Pismo Beach — City is having plans prepared for waterworks improvements including wells, pumping plants, etc. Estimated cost $35,000. S. G. Whittelsey, P. O. Box 188, is engineer.

Calif., Watsonville—Apple Growers Cold Storage Co. awarded contract for the construction of a cold storage plant, to F. L. Hoyt, 343 East Reed St., San Jose. Estimated cost $250,000.

Conn., Bridgeport — United Illuminating Co., F. Cutts, Mgr., plans addition to power plant on East Main St. Estimated cost $400,000. Engineer not selected.

Conn., Bristol—New Departure Mfg. Co., 269 North Main St., plans the construction of a boiler house to include four 600 hp. high pressure water tube boilers. Estimated cost to exceed $40,000.

Conn., Hartford—Hartford Electric Light Co., S. Ferguson, Pres., Pearl St., plans the construction of a 4 story power service building to house distribution and lighting departments on Sheldon St. Estimated cost $400,000.

Conn., New Britain—H. Doerr, 150 Shuttle Meadow Ave., awarded contract for foundation for a 25 x 70 ft. cold storage plant at Spring and Hartford Sts. to P. Kummer, Shuttle Meadow Ave., Estimated cost $40,000.

Conn., New London—U. S. Coast Guard Academy, Monegan Ave., plans the construction of an academy to include power plant, etc. Estimated cost $1,750,000. Private plans.

Conn., South Norwalk—Nash Engineering Co., Wilson Rd., plans the construction of boiler and transformer units. Estimated cost $40,000.

Fla., St. Petersburg—J. P. Jones plans the construction of an ice plant, ice tank engine room, condenser room, etc. Estimated cost $42,000. E. A. Nordstrom is chief engineer.

Ill., Bloomington—Citizens Water Supply Inc., will receive bids until Mar. 5 for the construction of a waterworks system including dam, 5,000,000 gal. filtration and softening plant, pumping station, etc. Estimated cost $1,250,000. Alvord, Burdick & Howson, 6 South Dearborn St., Chicago, are engineers.

Ill., Chicago—Chicago Bd. of Trade, awarded contract for the construction of a 44 story office and board of trade building at Jackson Blvd. and La Salle St. to Hegeman-Harris Co., 431 North Michigan Ave. Estimated cost $10,000,000.

Kansas — Quartermaster, War Dept., Washington, D. C., is having preliminary plans prepared for completion of field shops, hangars and headquarters buildings including central heating plants at Fort Leavenworth, and Marshall Field, Fort Riley. Estimated total cost $140,000.

Me., Old Town—Water District Commission will soon award contract for the construction of a pumping station and filtration plant. Estimated cost $50,000. Weston & Sampson, 14 Beacon St., Boston, are engineers.

Me., Van Buren — International Paper Co., 100 East 42nd St., New York, N. Y., plans the construction of a 20,000 hp. power plant on Fish River, also line from St. Leonard, Canada, to here, in connection with proposed paper mill. Estimated cost $1,000,000.

Mass., Newton Highlands (Boston P. O.) —City of Newton, awarded contract for the construction of a pumping station, etc., to DeCristofaro Bros., 38 Glendower Rd., West Roxbury. Estimated cost $141,951.

Mass., Watertown—Metropolitan Ice Co., 321 Washington St., Somerville, is receiving bids for the construction of an artificial ice plant here. Private plans.

Mich., Grand Rapids — City plans the construction of a sewage disposal plant, including pumping station, etc. Estimated cost $1,250,000. Pearse, Greeley, Hanson, 64 Michigan Ave., Chicago, Ill., are engineers.

Minn., Minneapolis — M. T. Baker Co., 330 Baker Bldg., awarded contract for addition to hotel at Marquette Ave. between 11th and 12th Sts. to Piper, Drake & Baker, 1138 Baker Bldg. Estimated cost $2,000,000. Steam heating system, etc. will be installed.

Miss., Ellisville—Building Commission, C. Trotter, Secy., Jackson, will receive bids until Mar. 7 for the construction of a power house, pump house, etc. for Mississippi School and Colony for Feeble Minded here.

Mo., Harrisonville—City, C. V. Lynch, Clk., will soon award contract for waterworks improvements, including dam, two 160 g.p.m. raw water centrifugal pumps and motors, two 300 g.p.m. high service centrifugal pumps and motors and one 1,200 g.p.m. filter wash water pump and motor, tank on tower, etc. Estimated cost $20,000. W. B. Rollins & Co., 339 Railway Exchange Bldg., Kansas City, are engineers.

Mo., St. Louis—Market Development Co., c/o C. E. Richardson, Pres. International Life Bldg., is having plans prepared for the construction of produce market including refrigeration plant, loading platforms, etc., at Chouteau and Rankin Aves. Estimated cost $2,000,000. Henchien & McLaren, 1637 Prairie Ave., Chicago, Ill., are architects.

Mo., St. Louis—Park Royal Syndicate c/o D. R. Harrison, 1106 Ambassador Bldg., Archt., will build a 15 story apartment building, including steam heating and electric refrigeration systems, etc., at 4605 Lindell St. Estimated cost $1,250,000. Work will be done by separate contracts.

Mo., St. Louis — Syndicate, c/o Mullin-Walters Realty Co., 824 Chestnut St., is having preliminary plans prepared for the construction of an 11 story studio apartment building, including steam heating and electric refrigeration systems, etc., at West Pine St. and Kingshighway.

N. J., Belleville — Bd. of Chosen Freeholders, Hall of Records, Newark, will receive bids about Mar. 15 for the construction of an 8 story hospital, nurses home, etc., including steam heating, ventilation and refrigeration systems, boilers, elevators, etc. Estimated cost $1,000,000. Sutton, Sutton & Calkins, 402 Broad St., Newark, are architects.

N. J., East Rutherford — Asiatic Petroleum Co. of New York Ltd., 65 Broadway, New York, is receiving bids for the construction of a 50 x 70 ft. boiler house here. Estimate cost $40,000. Private plans.

N. J., Elizabeth—White Ice & Supply Co., c/o W. Clifford, Jr., 1177 Grand St., Archt., is receiving bids for the construction of an ice plant at South 7th St., 4th Ave. and Elizabeth River. Estimated cost $50,000.

N. Y., Irondequoit (mail Rochester)—North Goodman Sewer Commission, will receive bids until Feb. 27, for the construction of a sewage system and pumping station in North Goodman Sewer District. J. P. Wells, 80 East Ave., Rochester, is engineer.

N. J., Newark—National Newark & Essex Banking Co., F. L. Farrell, Pres., 752 Broad St., is having plans prepared for the construction of a 32 story bank and office building, including steam heating and ventilation systems, boilers, elevators, etc., at Broad St. between Clinton and Commerce Sts. Estimated cost $10,000,000. J. H. and W. C. Ely, 205 Broad St., are architects.

N. J., Newark—United States Realty & Investment Co., W. E. Lehman, Pres., 972 Broad St., Archt. is having plans prepared for a 15 story office building including steam heating and ventilation systems, boilers, elevators, etc. at Broad and Bridge Sts. Estimated cost $1,500,000.

N. J., Trenton — State House Commission will soon award contract for the construction of a power plant. H. A. Kelly, Jersey City, is architect. J. O. Hunt is engineer.

N. Y., Brooklyn—Dept. of Welfare, B. S. Coler, Comr., Municipal Bldg., New York, awarded contract for the construction of a generating plant here to G. E. Gibson Co., 6th Ave. and 57th St., New York, also refrigeration and ice making plant to Carbondale-New York Co., 173 Christopher St., New York, and altering and constructing addition to power plant at Kings County Hospital here, to J. A. Lee, 3103 Farragut Rd., Brooklyn. Estimated cost $83,940, $57,200 and $18,500 respectively.

N. Y., New York—Alurion Realty Corp., W. T. Knight, Pres., awarded contract for the construction of a bank, office and stores building at 154 West 41st St. to Bricken Construction Co., 1385 Broadway. Estimated cost $3,000,000. Steam heating system, etc. will be installed.

N. C., Marshall — East Coast Utilities Inc., Chicago, Ill., plans the construction of a hydro-electric power plant on French Broad River near here. Estimated cost $250,000.

O., Cleveland — Cleveland Union Terminal Co., C. L. Bradley, Pres., Terminal Tower, awarded contract for the construction of six terminal houses, six circuit breaker houses and two motor generator houses to Hunkin-Conkey Construction Co., Newman-Stern Bldg. Estimated cost $200,000.

Ore., Portland—Brickenwald Supply Co., P. E. Froehlich, Pres., plans the construction of a 100 x 150 ft. cold storage plant and warehouse at 22nd and Quinby Sts. Architect and engineer not selected.

Tex., Eagle Pass — Maverick County Water Improvement Dist. 1, will soon receive bids for the construction of a hydro-electric power plant in connection with irrigation system. Estimated cost $1,800,000. Private plans.

Tex., El Paso—El Paso Electric Co., F. J. Gannon, Gen. Mgr., plans to expend $3,000,000 for increasing generating capacity of their system at different points throughout the state. Private plans.

Tex., Hearne—Pacific Fruit Express Co., c/o H. T. Whyte, Asst. Gen. Mgr. and Engr., 238 South Pacific Bldg., San Francisco, Calif., awarded contract for the construction of a 10 x 1,100 ft. icing platform including icing and unloading machinery here to R. E. McKee, El Paso, Tex. Estimated cost $33,000.

Tex., Rockport—P. Clark is having preliminary plans prepared for the construction of a 6 story hotel, including steam heating, ventilation and refrigeration systems, boilers, elevators, etc. Estimated cost $500,000. H. T. Phelps, c/o Hicks Bldg., San Antonio, is architect.

Tex., San Antonio—J. J. Nix, 205 East Travis Bldg., will receive bids until Mar. 12 for the construction of an 18 story office building including steam heating, ventilation and refrigeration systems, boilers, elevators, etc., at Navarro and College Sts. Estimated cost $1,300,000. Beretta-Stiles Inc., 1203 National Bank of Commerce Bldg., are architects.

Tex., San Antonio—Sunset Ice & Cold Storage Co. awarded contract for the construction of a 15 ton ice plant at 130 Lamar St. to L. T. Wright & Co., Builders Exchange Bldg. Estimated cost $28,000.

Tex., Snyder—Western Produce Co., J. P. White, V. Pres., Abilene, plans the construction of a produce plant including cold storage plant. Estimated cost $60,000. Private plans.

Va., Harrisonburg — Central Atlantic States Service Corp., plans the construction of a cold storage plant.

Wash., Kelso—Insland Power & Light Co., H. S. Gray, Gasco Bldg., Portland, Ore., plans the construction of a hydro-electric dam, 150 ft. high and 800 ft. long on Lewis river here to impound 42,000 acre ft. of water and develop 40,000 hp. Estimated cost $2,500,000.

Wis., Beloit—Wisconsin Power & Light Co., A. P. Gale, Dist. Mgr., is having plans prepared for addition to power plant. Estimated cost $50,000. Sargent & Lundy, 72 West Adams St., Chicago, Ill., are engineers.

Ont., Windsor—L. A. Merlo and J. H. Ray, c/o Merlo Merlo & Ray, Sandwich St., Ford City, is having plans prepared for an 18 story office building including steam heating system, etc. on Ouellette Ave. Estimated cost $1,500,000. Pennington & Boyde, 1002 Security Bldg., Windsor, are architects.

Quebec — James MacLaren Lumber Co., Buckingham, will soon receive bids for the construction of a power plant, 90,000 hp. initial capacity at High Falls on Lievre River near Buckingham with provision for installation of another 30,000 hp. unit, also dam at Cedar Rapids. Estimated cost approximately $5,000,000 and $1,500,000 respectively.

Equipment Wanted

Boilers, Etc.—Bd. of Education, F. G. Hogen, Dir., Cleveland, O., will receive bids until Mar. 11 for installing new steel boilers, at Quincy School. Estimated cost $25,000.

Boilers, Pulverizers, Pump, Generating Units, etc. — Building Commission, W. C. Trotter, Secy., State Capitol Bldg., Jackson, Miss., will receive bids until Mar. 7 for new boilers, unit pulverizers for firing boilers, new pump, moving and installing present pump, new steam driven electric generating units, moving and installing present air and ammonia compressors, new compressor, etc., for proposed service building and power house at East Mississippi State Hospital, Meriden, Miss.

Gas Plant Equipment — Fort William Gas Co., H. Price, Mgr., Fort William, Ont., prices and catalogs on equipment for gas plant. Estimated cost $1,000,000.

Generator—Signal Supply Officer, Signal Section, New York General Depot, 58th St. and First Ave., Brooklyn, N. Y., will receive bids until Mar. 12 for a generator.

Pumping Equipment—Village of Beulah, N. D., will receive bids until Mar. 5 for pumping equipment, etc., for proposed waterworks. Estimated cost $28,000.

Pumps — Fresno County Waterworks Dist. 1, D. M. Barnwell, Clk., Fresno, Calif., pumps, etc., for proposed waterworks improvements. Estimated cost $65,000.

Pumps, etc.—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Mar. 6 for pumps, etc., for proposed waterworks improvements at Dahlgren, Va.

Pumps, Etc.—City of Great Falls, Mont., plans to purchase pumps, etc., for proposed waterworks improvements. Estimated total cost $244,000.

Pumps, etc.—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Mar. 20 for motor driven pumps, etc., for proposed extension of portable waterworks system at Naval Ammunition Depot, Iona Island, N. Y.

Pumps, Etc.—Water Dept., W. McCaffrey, Supt., Oswego, N. Y., electric pumps, etc. Estimated cost $100,000.

Water Heater—U. S. Veterans Bureau, Washington, D. C., will receive bids until Mar. 5 for a boiler-feed water heater for U. S. Veterans Hospital, Maywood, Ill.

Industrial Projects

Calif., Alturas—LUMBER MILLS AND LOGGING PLANTS—Pickering Lumber Co., Crocker First National Bank Bldg., San Francisco, plans the construction of saw mills, logging plants and yards, etc. here. Estimated cost $3,000,000. Work will be done by owner's forces.

Calif., Stockton—GAS FURNACE FACTORY—Fraser Gas Furnace Co., 445 South San Joaquin St., is having plans prepared for the construction of a gas furnace factory on Fremont St. Estimated cost $50,000. R. P. Morrell, Mail Bldg., is architect.

Conn., Milford — RIVET FACTORY — Wright & Corson Co., 71 Charlotte St., Bridgeport, is having plans prepared for a 1 story, 25 x 112 and 155 x 250 ft. factory at Milford Turnpike. Estimated cost $150,000. Fletcher Thompson, Inc., 542 Fairfield Ave., Bridgeport, is architect.

Fla., Tampa — PHOSPHORIC ACID PLANT—American Cyanamid Co., 535 5th Ave., New York, has acquired a site and plans the construction of a plant etc. here. Estimated cost $1,500,000. Private plans.

Ill., East Peoria — FOUNDRY — Caterpillar Tractor Co., M. M. Baker, Local Mgr., awarded contract for a 2 story foundry to The Austin Co., 510 North Dearborn St., Chicago, Ill. Estimated cost $1,500,000.

Mich., Detroit—LEATHER STAMPING FACTORY—Chicago Raw Hide Co., 9000 Alpine Ave., awarded contract for a 1 story, 85 x 110 ft. factory to M. J. Hoffman Construction Co., 8505 West Warren Ave. Estimated cost $50,000. Equipment for the manufacture of leather stampings and gaskets will be installed.

Mich., Detroit—AIRCRAFT FACTORY AND POWER PLANT—Packard Motor Car Co., East Grand Blvd., will soon award contract for the construction of a 2 and 3 story, 65 x 125 and 63 x 185 ft., factory including detached power plant on East Grand Blvd. A. Kahn, 1000 Marquette Bldg., is architect. General assembly equipment will be required.

N. H., Laconia—KNITTING MACHINERY FACTORY AND BOILER PLANT—Scott & Williams Inc., 299 Union Ave., is having preliminary sketches made for additions and alterations to factory and boiler plant. Lockwood, Greene & Co., 24 Federal St., Boston, is engineer.

N. J., Newark — RADIO TUBE FACTORY—Sonatron Tube Co., 88 8th Ave., is having plans prepared for the construction of a 6 story, 68 x 120 ft. factory at 78-82 8th Ave. Estimated cost $175,000. Siegler & Greenberg, 164 Market St., are architects.

N. J., Perth Amboy — CABLE MANUFACTURING PLANT — Standard Underground Cable Co., 26 Washington St., is having preliminary plans prepared for a 1 story cable manufacturing plant. Estimated cost $200,000. Private plans.

O., Cleveland — COACH and BODY PLANT—American Coach & Body Co., J. Holan, Pres., 3809 Clark Ave., awarded contract for a 1 story, 60 x 200 ft. addition to plant to H. E. Klafman Co., 2844 Lorain Ave. Estimated cost $50,000.

O., Cleveland—RAYON FACTORY—Industrial Rayon Corp., F. C. Niederhauser, V. Pres., West 98th and Walford Sts., had plans prepared for a 1 story, 42 x 256 ft. addition to factory. Estimated cost $60,000. Christian, Schwarzenberg & Gaede, 1900 Euclid Bldg., are architcts.

Tenn., Memphis — WOODWORKING PLANT—Murray Body Corp., Clay Ave. and Russell St., Detroit, Mich., awarded contract for a 2 and 4 story woodworking plant here to Rock City Construction Co., Nashville. Estimated cost $2,000,000. Electric motors and woodworking equipment will be installed.

Ont., Toronto — ELECTRICAL MANUFACTURING PLANT — Canadian General Electric Co., 212 King St. W., awarded contract for a 1 story, 50 x 100 ft. addition to plant on Ward St. to Anglin-Norcross Ltd., Temple Bldg. Estimated cost $50,000.

Ont., Toronto—RADIO MANUFACTURING PLANT—Rogers Batteryless Radio Co., 90 Chestnut St., awarded contract for excavation for a 2 story 80 x 250 ft. radio factory on Fleet St. to Russell Construction Co., Harbor Bldg. Estimated cost $200,000.